The Foundry Trade Journal

AND PATTERN MAKER.

THE OFFICIAL ORGAN OF THE BRITISH FOUNDRYMEN'S ASSOCIATION.

Vol. 18. MARCH, 1916. No. 171.

PUBLISHED THE FIRST WEEK IN EACH MONTH.

Subscription Terms: 7s. 6d. per annum, post free.

To place the **"Journal"** within the reach of working Moulders and Pattern-makers, the Proprietors will accept subscriptions, not less than three in number from one shop, at the reduced rate of 5s. per annum, such order to be countersigned by the superintendent or foreman.

All communications to be addressed to the Editor, or to the Publisher, as the case may be, of

The Foundry Trade Journal,
165, Strand, London, W.C.

WE INVITE PRACTICAL ARTICLES ON THE TRADE IN ALL ITS BRANCHES, WHICH WILL BE PAID FOR. MSS. SHOULD BE WRITTEN ON ONE SIDE OF THE PAPER ONLY.

BRITISH FOUNDRYMEN'S ASSOCIATION.
LIST OF SECRETARIES—

General Secretary: E. A. Pilkington, Cottesmore, Oakham.
Manchester: A. Harrison, 705, Manchester Road, Castleton.
Birmingham: C. Grindlay, 39, Copeley Hill, Erdington, Birmingham.
Sheffield and District: J. Dickinson, 157, Abbeyfield Road, Pitsmoor, Sheffield.
Scottish: J. Macfarlane, 3, Sharrocks Street, Ibrox, Glasgow.
London: Alexander Hayes, 165, Strand, London, W.C.
Halifax: J. G. Robinson, 17, Gibraltar Road, Halifax.
Newcastle-on-Tyne: H. A. J. Rang, Cleveland Road, North Shields.
East Midlands: H. Pemberton, 15, Wolfa Street, Derby.

Contents.

	PAGE
Notes and Comments	127
German Shells and the Influence of Certain Elements on the Physical Properties of Steel	129
An Interesting Casting	131
Works of Mild Steel Castings, Limited	132
High-Speed Steel Tool Failures	134
Moulding Hand Grenades	135
Some Scientific Aspects of Steel Founding	137
Shells and Shell-Like Castings	141
Coke Consumption in the Cupola	142
Quick Production of Carbon Steels	143
New Open-Hearth Furnace Ports	144
Bottom Plates for Pouring Ingots	145
Canteen Construction and Equipment	146
Alloys of Chromium, Copper and Nickel	147
Reclamation of Magnalium from Turnings	149
Methods of Preparing Turnings for Packing	151
Seger Cones	152
The Weighing Problem in Shell Manufacture	153
The Brookhouse Moulding Machine	154
Correspondence	155
Non-Ferrous Notes	156
Trade Talk	158
Personal Paragraphs	160
Legal	160
Deaths	162
Applications for Patents	162
New Companies	164
Monthly Price List	166

Forthcoming Events.

MARCH 25.

British Foundrymen's Association: Newcastle-on-Tyne Branch.—Open Meeting for discussion.

British Foundrymen's Association: Scottish Branch.—Annual Business Meeting.

APRIL 1.

British Foundrymen's Association: Lancashire Branch.—Open Meeting for discussion.

APRIL 14.

British Foundrymen's Association: London Branch.—Short papers on foundry topics.

British Foundrymen's Association: Birmingham Branch.—"Some Characteristics of Iron: Thin Transmission to the Castings," by R. Buchanan, F.R.S.A.

NOTES AND COMMENTS.

Cast-iron Shells.

From time to time when the call for artillery munitions has been particularly insistent many foundrymen have asked why the Government does not follow the German plan and supplement the steel-shell supply with shells of cast iron. The War Office has in the past, however, persistently declined to consider the idea, as cast iron was not considered a suitable material for shells. The matter was referred to again recently in the course of a Paper on "The Manufacture of Shells and Shell-like Castings," read before the Sheffield Branch of the British Foundrymen's Association by Mr. J. T. Goodwin, who remarked that the manufacture of shells for filling with high explosives or for shrapnel purposes, and which were in contact with the explosion which ejected them from the gun, was an entirely different problem to the manufacture of those which were ejected otherwise. There had, he said, been considerable discussion as to why cast-iron shells should not be used for either of the above purposes and he was of the opinion there was a great deal of prejudice which prevented their use.

First, however, must be considered the fact that the shortage in shells in the past has not been so much in regard to the steel cases as the remaining parts; and no increase of shell cases by reason of using cast iron could have increased the output of complete shells. Should the supply of steel for shells, for some at present quite unforeseen reason, fall short, we are certainly of opinion that the official objections to cast iron could be overcome by a suitable mixture and proper methods of manufacture. There is more than most people believe in Mr. Goodwin's contention that it is possible to obtain a mixture which would give the necessary tensile strength and allow the walls of the shell to be reduced and give a lighter shell. To overcome the bursting effects of the "blow-back," he suggested corrugating the interior, at an angle giving a larger sectional area; the shell, upon explosion, would thus break along the lines of least resistance by following the angle of the corrugations and break up into more effective pieces than if it had straight sides. There is no doubt that such castings could be cast with great accuracy, even to the limits specified for machining, and the machining could be reduced and the output increased if the body and nose were accepted unmachined. The main objection to this that has been raised in the past has been that the hard skin of the casting would injure the gun barrel; but as these castings would be annealed and sand-blasted to a polish, Mr. Goodwin contends that this defect would disappear. There was also the question of unequal thickness of the shell walls; after experimenting in the methods of manufacture this difficulty was overcome, and a limit of thicknesses error in the shell walls of 0.02 in. was obtained. If it were possible for cast-iron shells to be accepted, there would be no difficulty, he thought, in obtaining an output of 4-in. or 6-in. shells at the rate of 200,000 per week.

While agreeing in the main with these contentions, it must be remembered that carefully standardised methods and fine workmanship would be necessary, or a grossly disproportionate number of castings would be rejected by the inspectors and the cost of producing perfect castings would be prohibitive. This does not mean that, given the demand, such castings could not be produced commercially; but in work of this description the numerous little irregularities that might pass muster in other work are rigidly ruled out. One feature of cast iron which is highly desirable in shells is its resistance to deformation under compression; for the stresses on a shell in the gun, of course, are compressional and not tensional.

Shell Steel.

So far as steel for shells is concerned, some interesting information is contained in the Paper presented by Dr. Stead before the Cleveland Institution of Engineers (see page 129). From the evidence afforded by the analyses it would appear that basic-Bessemer steel is being used for German shells, while the proportions of various constituents are by no means in keeping with British specifications. Dr. Stead suggests that either the German authorities have been careless in their selection of steel, or that their experts have found that great latitude in composition and physical properties is permissible. The first hypothesis he dismisses as absurd. But in the light of the official disregard for life which other German actions have revealed it may not be so absurd. It may be, indeed, that both suggestions are true within limits. If they care to take the risk of losing a small percentage of guns and gun crews by prematures, they can not only afford to fire cast-iron shell, but also steel shell of still more variable and uncertain chemical composition; and this, translated into the arts of peace, is the German principle in quality of manufacture. They do not produce the best, but something that is cheaper, and which in ninety-nine cases out of a hundred will serve. At the same time, their willingness to take such risks, even if that be accepted, is no real proof of the danger of cast-iron or steel shells of the composition in question.

The analyses of shell steel specified by other nations also show great variations. One shell specification puts the following chemical limits on the steel:—Carbon, 0.34 to 0.42 per cent.; manganese, 0.55 to 0.75 per cent.; silicon, 0.15 to 0.25 per cent.; phosphorus, 0.03 to 0.08 per cent.; and sulphur, not more than 0.05 per cent. A high-explosive shell specification puts the manganese limits at 0.4 to 1.0 per cent., and fixes maximum limits as follows:—Carbon, 0.55 per cent.; nickel, 0.5 per cent.; silicon, 0.3 per cent.; sulphur, 0.05 per cent.; phosphorus, 0.05 per cent.; and copper, 0.1 per cent. Dr. Stead suggests wider limits in specifications, and, of course, we can still go a good way and yet not reach the German phosphorus figures. During the war the phosphorus limit has been increased, and if the French War Office will accept 0.08 there should be very good reasons advanced before requiring a lower limit in this country.

German Manganese Shortage.

When German steel analyses are under discussion it is only natural to look for evidence which will give some key to the manganese position in that country. From the high manganese content of all but one of the analyses given it may be presumed that the shells discussed by Dr. Stead were made prior to the war or early during the war, before the manganese scarcity in Germany became serious. The Dunkirk shell quoted shows the low manganese content of 0.38 per cent. and is probably an indication of marked economy in that element at a later date of manufacture. But while it is known that Germany is suffering from a shortage of ferro-manganese, it must be remembered that a large proportion of her steel output (probably larger now than previously) is basic-Bessemer material, for which the use of spiegeleisen instead of ferro-manganese is suitable. Germany has no serious supplies of manganese-ore proper, but she has certainly an ample native supply of manganiferous iron ore; the output of such ore running from 12 to 30 per cent. of manganese was 300,000 tons in 1912, and of ore containing up to 12 per cent. of manganese nearly 3 million tons. In a review of the steel industry in the first year of the war, given by Dr. Schrodter in "Stahl und Eisen," he remarked that the way in which Germany got over the difficulty of manganese shortage was a secret, but that "the idea of a dearth of steel for our war needs because of a collapse of our steel industry is a miscalculation." It has also been recently asserted by others that the problem of finding a substitute for ferro-manganese in Germany has been solved. It is claimed that the new material can be made from elements abounding in profusion in the country, and that already plants are at work upon its manufacture, while others are in course of construction for the same purpose. While we do not accept these assurances quite at their face value, there is no doubt an element of truth in them. A spiegel running as low as 10 per cent. of manganese—the Germans can make a great deal of this—will contain only 5 per cent. of carbon, and therefore in making a steel containing, say, 0.40 per cent. of manganese only 0.20 per cent. of carbon is introduced. Clearly in shell steels there is no insuperable drawback about this.

Cupola Heights and Efficiency.

On another page the subject of coke consumption is briefly dealt with by Mr. M. E. Gallon, whose main contention is to the effect that the height of the cupola stack is an important matter affecting the coke consumption for a given output and rate of pouring. The height of stack from tuyeres to charging door in most cupolas is purely arbitrary, and most published figures are based rather on what is accepted as fairly good practice than on proven law; while, also, the effect of this particular factor is generally obscured by other variables such as blast pressure and density of the charge. But as a generalisation we are in accord with Mr. Gallon's contention that the higher the stack, within practical limits, the greater the efficiency of the furnace. Whether the increased height is effective by reason of the longer contact of the hot gases with the iron, longer contact with the coke, or by creating increased resistance to the travel of the gases has not yet been determined. It would be most reasonable to assume that the increase in efficiency was rather by simple abstraction of heat by the iron from the gases passing upwards than by a more nearly complete combustion of the carbon. The amount of oxygen blown in is not affected by the height of the stack, and if that oxygen combines in the melting zone to CO_2 the only further change it can make is $CO_2+C=2CO$, resulting in waste of fuel without heating further. If, on the other hand, there is a proportion of the oxygen already passing off as CO, resulting from imperfect combustion, no increase in height will alter the fact, though it would abstract a little more heat from those gases the same as with CO_2 or any other hot gas.

German Shells and the Influence of Certain Elements on the Physical Properties of Steel.*

By Dr. J. E. Stead, F.R.S.. D.Sc., etc.

The German shells thrown on to the North-East Coast on December 16, 1914, have afforded great interest to the analysts who are members of the Cleveland Institution of Engineers, and who, instead of hoarding the fragments as mementoes of the bombardment, used them for the purpose of determining their composition. During the early part of last year it was considered advisable, as far as possible, to assemble these analyses, and with that object in view I have approached all the analysts who have interested themselves in the matter, and they have readily forwarded to me their results. Other members who had obtained specimens handed them over to me, and these were analysed by my assistants. This Paper must therefore be regarded as the work of the following gentlemen :—Mr. Frank Saniter, of the South Durham Steel Works, West Hartlepool; Mr. D. Sillars, of Messrs. Bolckow, Vaughan & Co., Ltd., South Bank; Messrs. Wilson & Bainbridge, of the Skinningrove Iron Co., Ltd., Carlin How; Mr. Braithwaite, of Messrs. The Cargo Fleet Iron Co., Ltd., Middlesbrough; Mr. E. W. Jackson and Mr. A. Scholes, of Messrs. Pattinson & Stead.

Description of the Shells.

The pieces analysed in most cases were small fragments, and it was consequently impossible to judge of the dimensions of the shells of which they formed a part. Judging from information received from Hartlepool and other places, it is certain that there were shells of many sizes—from 11.2-in. armour-piercing shells down to 4-in. high-explosive shells. Many of the larger shells had not burst, and it was possible to measure them. Shrapnel shells do not appear to have been used.

The shells used may be divided into two classes, namely :—(1) Armour-piercing shells; (2) high-explosive shells. The armour-piercing shell fragments were easily detected by the presence of nickel and chromium—elements universally added to steel used in that connection. It may be noted that the Germans affixed to the armour-piercing shells the soft nose pieces which are invariably used with shells of this description. The analyses of fragments of these shells were made by Mr. F. Saniter, and were as follows, namely :—Iron (by difference), 91.862 per cent.; carbon, 0.840 to 0.50 per cent.; manganese, 0.381 per cent.; silicon, 0.401 to 0.42 per cent.; sulphur, 0.033 to 0.028 per cent.; phosphorus, 0.032 per cent.; nickel, 3.100 per cent.; chromium, 3.351 per cent.

High-Explosive Shells.

The several analyses, and their sources, are given in Table I. :—

TABLE I.—*Analyses of High-Explosive German Shells.*

Where found.		C.	Mn.	Si.	S.	P.	Cu	N.	Tenacity	Analysis
West Hartlepool	1	0·60%	0·73%	...	0·062%	0·085%	..	...	...	Wilson
Do.	2	0·70%	0·80%	0·35%	0·027%	0·043%	...	..	55	Pattison & Stead
Do.	3	0·670%	0·515%	0·336%	0·037%	0·048%	0·083%	...	62	Do.
Do.	4	0·870%	1·094%	0·252%	0·037%	0·028%	0·080%	...	65	Do.
Do.	5	0·465%	0·794%	0·324%	0·038%	0·028%	0·090%	...	55	Do.
Do.	6	0·600%	0·655%	0·597%	0·046%	0·051%	...	...	...	F. Saniter
Do.	7	0·820%	1·266%	0·186%	0·048%	0·052%	...	..	...	Do.
Do.	8	0·765%	0·655%	0·364%	0·030%	0·045%	...	...	...	Do.
Do.	9	0·630%	0·550%	0·400%	0·042%	0·077%	...	...	...	Do.
Do. 8in. sh.	10	0·86%	1·03%	0·186%	0·053%	0·045%	...	...	..	Do.
Do.	11	1·12%	1·00%	0·23%	0·054%	0·038%	...	...	...	Bainbridge
Whitby & Scarbro'	12	0·850%	1·330%	...	0·080%	0·105%	...	..	...	Wilson
Do.	13	0·60%	1·21%	0·334%	0·071%	0·069%	...	0·0112%	59	Pattison & Stead
Do.	14	0·74%	1·170%	0·261%	0·044%	0·064%	...	...	62	Do.
Dunkirk	15	0·675%	0·380%	0·078%	0·083%	0·043%	...	...	...	Bainbridge
Ypres	16	0·700%	1·108%	0·221%	0·041%	0·079%	...	...	...	Pattison & Stead
Flanders	17	0·98%	1·05%	..	0·055%	0·086%	...	...	...	Wilson & Bainbridge
Do.	18	0·93%	0·98%	...	0·059%	0·065%	...	...	...	Do.
Do.	19	0·74%	0·98%	...	0·054%	0·050%	...	...	...	Do.
German	20	0·393%	1·400%	0·210%	0·035%	0·041%	...	...	...	Sillars
France	21	0·930%	0·970%	0·164%	0·032%	0·048%	...	...	...	Do.

Most of the fragments examined were small, and the fractures generally indicated material of very high tenacity. There were a few large pieces, and these had a much coarser crystalline structure than the smaller ones. It is well known that the appearance of the fractured surfaces of metals broken by sudden shock is a very useful guide in forming a correct judgment of the physical character of the material. If the surfaces are more or less coarsely granular, and the fracture has travelled in straight planes, the material is usually relatively weak. Such fractures somewhat resemble the fractures of lump sugar. If they are more finely granular the surfaces are not usually flat, and frequently have tongues or pointed strips of metal attached to the

* Read before the Cleveland Institution of Engineers.

fracture, suggesting a tearing action and tough material.

Some of the inner and outer surfaces of the shell fragments were fissured by a multitude of fine cracks, generally parallel to the vertical axis of the shell. The flat surfaces of one of the base plugs where it came into contact with the explosive charge were similarly broken up into fissures, but these did not extend to the outside of the plug. The force must have been of such violence as to tend to tear the metal to pieces and produce disintegration.

One writer in describing the German shell fragments said :—" One can have little conception of the terrible nature of these until they are handled. They bristle all over with horrible points and edges —some as keen as a razor." One peculiarity is the manner in which the fragments broke, leaving what may be described as " sheer fractured surfaces," with sharp knife-like terminations. The tracks of the fractures were often at angles of 35 deg. to 45 deg. to tangents of the shells, and the broken surfaces of many of them had a somewhat fibrous appearance characteristic of great toughness. Tests made on the fragments of both the coarsely granular and fibrous varieties confirmed the conclusion that the former were brittle and the latter extremely tough.

The fragment corresponding to analysis No. 13 was particularly interesting. It had " sheer fractures " on both its sides, was of fine crystalline structure, and evidently ideal in its character, yet this contained about 0.07 per cent. sulphur, and the same amount of phosphorus. Moreover, it contained 0.011 per cent. nitrogen, an indication that it was made by the Bessemer process, for no open-hearth steel, so far as is known, contains nearly so much of that element. As acid-Bessemer converters are rare, if not non-existent, in Germany, it is justifiable to conclude that the steel is basic-Bessemer. It had a fine micro-structure with practically no free ferrite, due to the exceedingly high manganese content. In metallographical terms the steel was sorbitic, consisting of unsegregated pearlite. On reheating to about 800 deg. C., and cooling in about half an hour to 400 deg. C., and then to 15 deg. C., its original structure and hardness were reproduced. The Brinell hardness number was 255, equal to about a tenacity of 56 to 57 tons per sq. in. What the elongation was could not be determined, but it certainly would not exceed 12 per cent.

Little comment is necessary on the armour-piercing shells. A broken piece from the point was exceedingly hard, as indicated by the Brinell machine. The shell had evidently exploded on coming into contact with something not hard enough to damage the point itself.

The Seaton Carew Ironworks, and the West Hartlepool Works of the South Durham Steel and Iron Company, Limited, were marks for the German gunners, but the shells either fell short or passed right over the works, with the exception of one or two small shells which did little damage.

On examining the analyses of the high-explosive shells, one cannot help being struck with the very wide range in the composition. Comparing the maximum and minimum amount of each element, we have :—Carbon, 0.393 to 1.12 per cent.; manganese, 0.380 to 1.40 per cent.; silicon, 0.078 to 0.597 per cent.; sulphur, 0.027 to 0.083 per cent.; phosphorus, 0.028 to 0.105 per cent. Out of the twenty-one analyses, ten show more than than 1 per cent. manganese; seven show more than 0.3 per cent. silicon; twelve more than 0.2 per cent. silicon; three show more than 0.07 per cent. sulphur; eight more than 0.06 per cent. phosphorus. The average per cent. of carbon is 0.75 per cent.

What is the reason for these variations? One cannot, of course, say with certainty, but there are only two explanations one can offer :—

(1) That the German authorities have been careless in their selection of the steel. That the occasional premature bursting of a shell in a gun and the consequent destruction of the gun and gunners did not matter, as they had so many guns and men to spare—a suggestion actually made in this country, but which is obviously absurd. (2) That the German experts have found that, provided the steel is suitable for the purpose required, a great latitude in the composition and physical properties is permissible.

The first hypothesis may be dismissed without much consideration; the shells sent into our towns, varying greatly in composition, obviously did not burst in the gun, and moreover, seeing that the Germans have devoted more time and money and thought to the preparation for this war than any other people, we must admit they know what they are doing at least as well as we do. An examination of the larger fragments of German shells did not lead to the discovery of anything in the nature of rokes or surface flaws, and the very high percentages of silicon and manganese in most of them suggests that soundness was considered as of primary importance. The fact that nitrogen was found in a relatively large quantity in one of the best specimens, leads to the conclusion that nitrogen is not harmful, and that probably basic-Bessemer steel has been found quite suitable, provided a sufficient quantity of silicon and manganese is present to ensure soundness.

Any intelligent person with no engineering or special knowledge of the subject would tell us at once that the stresses put on a shell in the gun are compressive not tensional. That if the shell were made of lead instead of steel, the sudden compressive force applied to the base would cause the shell walls to bulge outwards, and to become reduced in length, and that very soft steel would probably behave in the same manner. Therefore, the Germans were careful to avoid this, and made steel strong enough to resist deformation by compression in the guns. We may conclude, therefore, that what was feared was bulging more than breakage by shock. It cannot be denied by anyone who knows, that steel containing 0.75 per cent. carbon and above 1.2 per cent. manganese is brittle to shock, and that if such material were made into a rail and were tested in the usual way, it would fly to pieces under a falling-weight test; yet steel shells of that description did not burst in the German guns, but burst on us. Every rail-maker knows that a shell containing 0.10 per cent. sulphur and phosphorus, 0.45 per cent. carbon, and 0.8 per cent. manganese would be less liable to break under shock than such steel if sulphur and phosphorus were entirely absent.

What must be avoided is anything at all likely to cause explosion of the shell whilst in the gun itself. There are several conditions which might lead to premature explosion :—(1) Defective fuses; (2) the possible formation of sensitive compounds such as picrate of lead and other metallic picrates due to the accidental presence of particles of lead, etc., which on being acted on by picric acid might lead to the formation of the sensitive salts referred to; (3) gross porosity of the base of the shell sufficient to admit hot gases from the ignited propellent; (4) allowing the shells to rest for a long period in a very hot gun tube, whereby the detonator explodes and the charge is fired; (5) shells made of steel of too soft a character, causing bulging and

excessive friction between the shell walls and the sides of the gun tube, leading to the accentuated pressure of the propellent gases exceeding the bursting pressure; (6) excessive brittleness of the steel.

It is obvious that when a gun has burst it is impossible to say whether the fuses have been defective, or whether the cause has been the presence of explosive picrates, or whether the steels have been porous. It might be possible to determine whether the shell jammed or the steel was excessively brittle. Those who loaded the shells and fixed the fuses of course could not be convicted, no matter how badly their work was done. Yet I, myself, have seen a shell burst directly it left the gun tube, an occurrence which could only be explained on the assumption that something was wrong other than the steel itself. The officer in charge concluded that the fuses were at fault.

The analyses of the German shells naturally make us question our own practice and specifications, which lead to the rejection of material such as would be accepted in Germany. Our authorities may have proofs I do not know of justifying their specifications, but to say that because a shell has burst in a gun therefore the steel is at fault is not justifiable; neither is it justifiable to form any dogmatic conclusion without ample proof. One method of testing shells gives conclusive proof that steel of a certain origin which is not at present admitted by our authorities, is quite suitable for high-explosive shells. Further trials are projected which it is proposed to ask some of the gentlemen responsible for our specifications to attend and witness. One thing which must be admitted is that if a steel is proved by suitable mechanical testing to be satisfactory, on no account should it be rejected on chemical analyses, for one remembers that mechanical testing is the base on which rests all chemical specification.

In conclusion, judging from the analyses of the German shells, it would appear :—

(1) That our enemies are not particular in having shell steel of uniform quality.

(2) That the steel used is generally of relatively high tenacity, and much more liable to break up by shock than what we produce and prescribe.

(3) That most probably some of the German shells are made by the basic-Bessemer process, judging from the relatively large amount of nitrogen present in one of the toughest and best fragments, which also contained 0.07 per cent. sulphur and phosphorus.

(4) That the analyses of the armour-piercing shells correspond with analyses of similar material made in other countries.

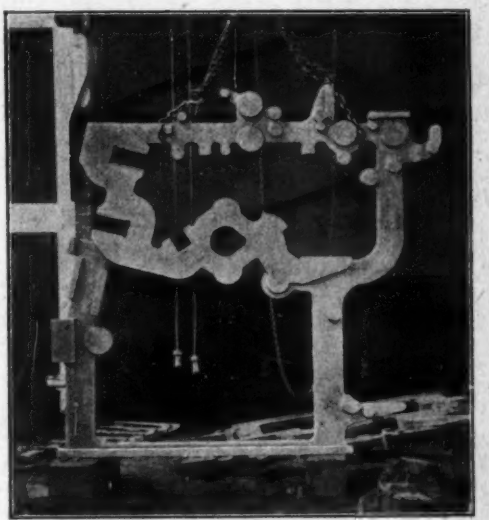
(5) That if the high-explosive shells with between 0.07 and 0.1 per cent. phosphorus did not burst in the gun, it seems probable that great freedom from that element has been found to be unnecessary.

In view of these considerations is there not reason for our authorities to doubt the expert advice given them—on which, of course, they must depend—to restrict so drastically the allowable quantity of both sulphur and phosphorus, thereby restricting the output of shell steel? As the question can so readily be settled by making suitable mechanical tests on the finished shells, such as I myself have made with convincing result on material at present barred, is it not in the national interest that such tests should be made without delay by the authorities at headquarters?

If the results of my mechanical tests are confirmed, then the obvious thing to do is to alter the specifications forthwith. If the mechanical tests are found to be conclusive, then it would be a national crime to reject material on any chemical specification before submitting the steel in question in the form of a finished shell to the more convincing mechanical test.

An Interesting Casting.

The accompanying illustration shows suspended an interesting casting in iron—one of two large printing-machine frames made by the fast-ramming method described by Mr. M. E. Gallon before the British Foundrymen's Association. (See FOUNDRY TRADE JOURNAL, February issue.) On a bogie in the



stove behind can just be seen a mould for a large clay-mill roller 6 ft. dia., 14½ in. face, and weighing 30 cwts. The core was made in loam, and the outside rammed with the feet and cast green, the same as the frames mentioned. All three castings were perfect.

RESEARCH LABORATORY FOR MIDDLESBROUGH.—At a recent meeting of the Cleveland Institution of Engineers, at Middlesbrough, Dr. J. E. Stead, F.R.S., urged the establishment of a Research Committee of the Institution, and also of an engineering and metallurgical laboratory for Middlesbrough in which all up-to-date mechanical testing could be done by those who prosecuted researches on the properties of metals. There seemed, he said, little present prospect of the establishment of a technical college in the town, and as they could not afford to stand still, if they could not get the greater they must be content for the time being with the lesser. An inexpensive building could be erected and equipped for a few thousand pounds, and even a sheet-iron building would do for a start. The staff need not be large, and the annual cost need not exceed £500. So imperative was the need that, having regard to the fact that the laboratory would have to be paid for and supported by Middlesbrough people, he had pleasure in offering £500 as a beginning. He hoped the iron and steel firms in the district would subscribe in proportion to their capital. If that were done they would have the laboratory paid for in a few weeks, and built in as many months. He made these suggestions as a means whereby Middlesbrough would be helped forward to the greater position it ought to hold. He hoped the whole subject would be referred to the Council for careful consideration. Dr. Stead's proposals were received with enthusiasm, and were referred to the Council as he suggested.

Works of Mild Steel Castings, Limited.

Mild Steel Castings, Limited, is a development of a business which was established at Wellington in 1908 under the style of the Sinclair Mild Steel Castings Company, Limited, but although a certain number of castings were made for local consumers the works were not laid out with a view to developing in this direction, the main objective of the Company being the sale of their patent crucible furnace, designed for the production of castings of low-carbon steel which are ready for machining so soon as they leave the mould, no annealing being required. Such metals as high-speed tool steels, nickel, brass, etc., were also melted. To demonstrate the practicability of the furnace, work had of course to be carried out on a commercial scale, with the result that the demand for castings soon exceeded the capacity of the plant. The management, therefore, whilst not losing sight of their first objective—the sale of furnaces—decided to develop the foundry side of the business, to which end the works were transferred to the neighbourhood of Birmingham some five years ago, where they commenced to trade under the present style: Mild Steel Castings, Limited, Mr. W. H. Watkins and Mr. W. S. Knight being appointed general manager and works manager respectively.

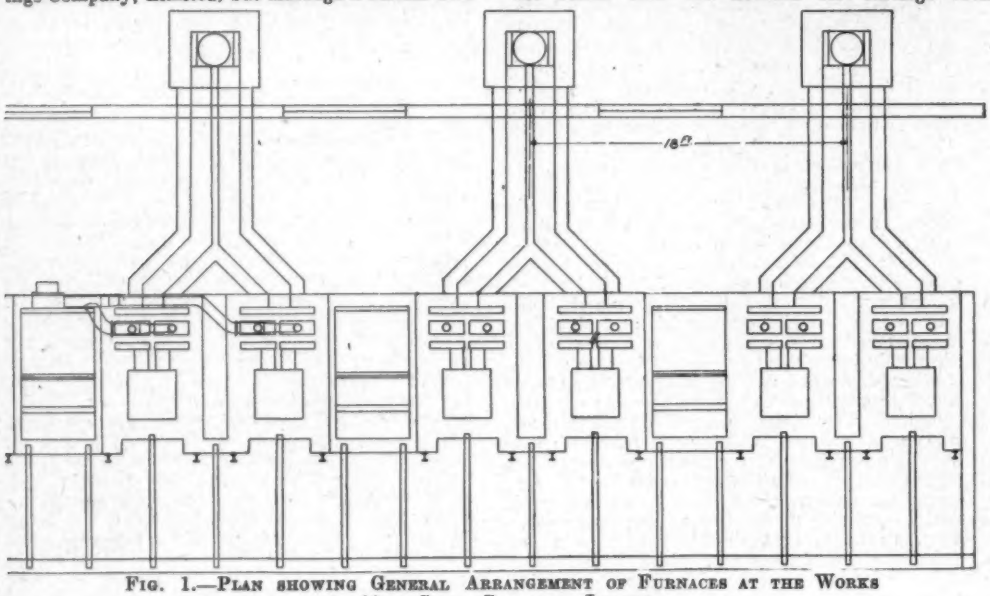


FIG. 1.—PLAN SHOWING GENERAL ARRANGEMENT OF FURNACES AT THE WORKS OF MILD STEEL CASTINGS, LIMITED.

When further extensions became necessary it was decided to lay down an entirely new foundry. The site, where the company have acquired a considerable tract of land which provides for liberal exten-

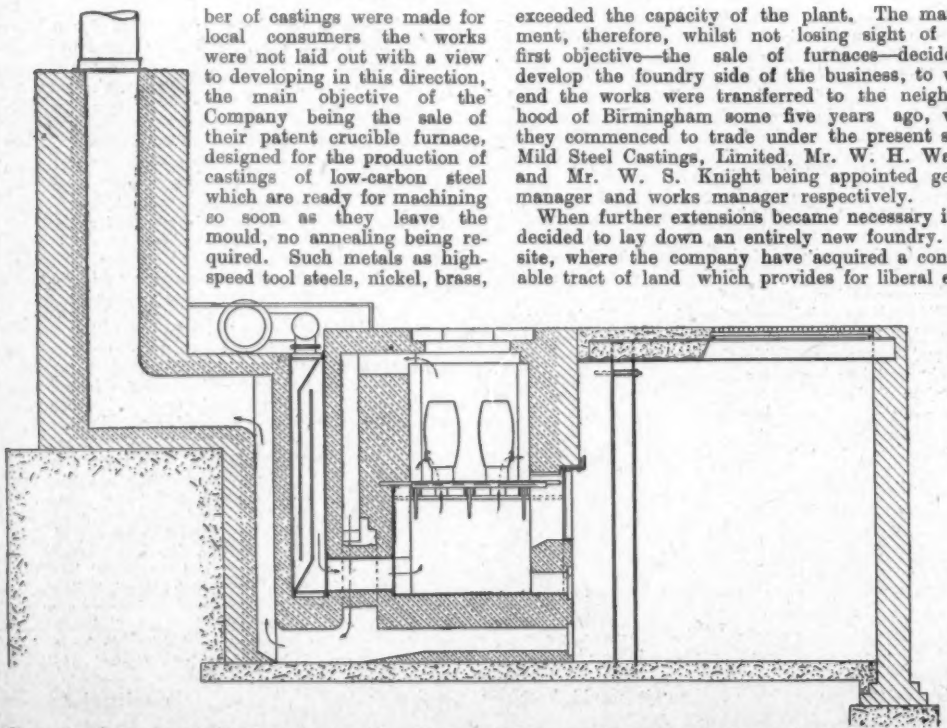


FIG. 2.—DETAILS OF CONSTRUCTION OF A TYPICAL FURNACE; MILD STEEL CASTINGS, LIMITED.

FIG. 3.—VIEW IN FOUNDRY BEFORE COMPLETION (FURNACES IN BACKGROUND); MILD STEEL CASTINGS, LTD.

FIG. 4.—VIEW IN FETTLING SHOP; MILD STEEL CASTINGS, LIMITED.

sions, is at King's Road, Hay Mills, about three miles from Birmingham and in close proximity to the Great Western Railway main line to London. Comparatively few years ago Hay Mills was a rural district, but with the diversion of the Great Western Railway traffic in this direction, the district has developed with great rapidity.

The works of Mild Steel Castings, Limited, front on to King's Road and adjoin the office buildings. The floor space covered by the works is 120 ft. by 110 ft., spanned by four bays. The first bay is taken up by ten 4-pot melting furnaces, the second and third bays serve as the casting floor; here also are two gas-fired drying stoves, and at one end the sand-grinding and mixing shop, whilst the last bay is equipped as a fettling shop.

The foundry itself is being laid out with a view to repetition work, some machines being already installed, and others will be erected as soon as they can be got from the makers. Interest naturally centres in the capacity and working of the furnaces. The general arrangement of the furnaces is shown in Fig. 1 and the details of construction of a typical furnace in Fig. 2. Each furnace, it will be noted, consists of a pot-hole for four pots, the furnace having a total melting capacity of 300 lbs. of mild steel. Each pair of furnaces is equipped with a Keith-Blackman 10-in. fan direct-motor-driven and taking approximately 1½ h.p. The blast pressure ranges from 4 in. w.g. when melting mild steel down to 1½ in. w.g. when melting tool steel, brass, etc. It will be noted that the blast pipes serving the pot-holes are controlled by dampers, so that either hole can be worked independently.

The special features of the furnace lie in its regenerative principle, whereby the heat from the waste gases is utilised to pre-heat the air before its entry into the furnace, and in the method of and point at which that air is admitted. It will be seen that the fan delivers into what may be described as a blast chamber, consisting of a sheet-steel box fitted with two internal baffle plates, which cause the blast to travel three times the length of the chamber before it is admitted below the firebars, so that the blast does not come into direct contact with the pots—a by no means unimportant factor. The waste gases, it will be seen, on leaving the furnace pass round the blast chamber, heating it to a dull red, on their way to the chimney.

A charge of mild steel (carbon 0.1) is melted in from one and a half to two hours, with a consumption of from 1.3 to 1.5 cwt. of coke to 1 cwt. of metal. It is also worthy of note that brass (or any copper alloy) can be melted with the latent heat in the furnace after each steel melt in about half an hour. And as no air passes through the furnace at this stage the loss in melting, due to oxidation, is reduced to a minimum.

As previously stated, the castings are made in green sand and require no annealing; whilst being low in carbon, sulphur, and phosphorus, and of the same texture all through, *i.e.*, containing no hard spots, they machine very easily. The tensile strength of the castings is approximately 32 tons per square inch, with an elongation of 25 per cent. on 2 in. The best-quality castings can be case-hardened by any usual process, and all may be welded by the oxy-acetylene process.

We understand that the furnaces have also been successfully adopted for melting tool steel, as evidence of which we are able to give results of working, furnished by a Lancashire company :—

Coke consumed per ton of metal melted ...	1.44 tons.
Life of clay crucibles	2.5 to 3 heats each.
Capacity of furnace ..	4 pots each containing 70 lbs.

Three heats per day obtained with each furnace.

High-speed Steel Tool Failures.

Writing in the "Railway Age Gazette," Mr. G. J. Brunelle points out that in the case of a high-speed steel which serves general purposes fairly well, there are several causes that will make it fall below its general standard when formed into a tool. The following are attributed to the toolsmith :—

Forging.

(1) Heating too fast.
(2) Not heating uniformly.
(3) Over-heating.
(4) Forging too cold.

Heat-Treating.

(5) Over-heating.
(6) Keeping at high temperature too long.
(7) Heated insufficiently to get maximum high-speed properties.

Thus there are at least seven possible faults attributable to the toolsmith in a properly shaped tool, each of which will impair its usefulness, and if avoided there are others which would prevent its coming up to its standard, viz. :—

Due to Grinding.

Cause.	Effect.
Too fast on dry wheel.... ...	Soft edge.
Too fast on wet wheel	Cracks.
Not ground enough	No edge.
Too much clearance	Crumbles.
Too much rake	Breaks.
Too much shear	Breaks.
Ground to negative rake ...	Breaks.
Not enough shear	Cuts rough and seems dull.

Due to Abuse.

Cause.	Effect.
Too much overhang	Tool chatters.
Material not annealed	Tool seems soft.
Too much speed...	Tool seems soft.
Chip too large	Tool breaks.
Chip too small	Tool not under scale : tool seems soft.
Gritty material	Tool edge grinds off.

There are yet other causes not chargeable to either smith or machinist that may nullify their best efforts towards producing a good tool. The steel may be incapable, at its best, of sustaining its edge at the required speed, perhaps a cheap steel or one intended for tools of delicate shape, where toughness is a primary consideration. It may also have been forged in a coal fire that had an excess of sulphur and phosphorus, or a furnace of "home make" where the heat is forced through the steel from one side. Lastly, by no means the most uncommon cause of failure is a wet air blast, which is sure to cause a tool to "flake off the top."

BRITISH PATENT LAWS.—In a letter strongly advocating a revision of the British Patent System, Mr. James Keith states that in the overhauling again of our Patent System there should—amongst other things—be included :—(1) A real search to ensure novelty and validity before any application for patent be entertained. (2) No patent to be granted unless novel or practicable. (3) The entire abolition of all renewal fees. (4) The extension of the period for each patent from fourteen to seventeen years. (Both 3 and 4 as in the United States.) (5) Some form of guarantee for a bona-fide inventor. (6) Simplified Court procedure in Patent cases, so as to limit the frightful expense of patent litigation. In the formulation of any new Patent Act inventors, engineers, and business men should be called into consultation more than patent counsel, lawyers, and patent agents, as has hitherto been the case. Then, with the indispensable Minister of Commerce or Industry, so long rightly clamoured for by the Chambers of Commerce and other representative bodies throughout the United Kingdom, and these moderate advantages enumerated, Great Britain, after the war, would be brought into something like line with the United States, its principal future competitor in the world's trade, and so have every chance of holding its own.

Moulding Hand Grenades.

By Allan Hill.

The hand grenades which are being used to an enormous extent in the present war are of various types, but are generally round or oval in outline, and are made of various materials; but the most destructive have been proved to be those made of cast iron, and the moulding of these will be described by the writer. The weight varies in different designs, but each design must be kept to its given weight, so the best method of moulding is by machines, which keeps them to a perfect shape as well as a correct weight, and is more sure than ordinary pattern-plate moulding on the floor.

The making of these grenades involves large outputs at low costs, and as large numbers of foundries are engaged in their manufacture competition is very keen. The biggest proposition is in obtaining the cores. They are not difficult to make, but if ordinary methods are used a large amount of labour is required, for one moulder will use more in a day than one core-maker can make in two days. The sand must be such as to make a solid core that can be handled without damage, allow free venting, leave a smooth skin on the inside without having to resort to the use of blacking, and also enable the core to be removed from the casting whilst in the tumblers. Oil-sand mixed in the right proportions will be found to be the most satisfactory, as it will fulfil all the conditions mentioned, the following being the mixture used:—1 barrow of dry rock sand, ½ barrow of sharp sand, 1 quart of boiled linseed oil. These must be thoroughly mixed so as to give a regular mixture, and this mixture is given its working degree of dampness by the addition of water. The core-boxes also must be kept well oiled with paraffin, and kept warm; if this is not done the sand will adhere to the box.

Various methods of moulding have been adopted, each establishment using its available appliances, converting them for the purpose and no doubt following their own practice as far as possible. The following are the methods used in a large Lancashire foundry, where quantities of two types are being turned out, one a round one, the other an oval one which goes by the name of "Mill's grenade."

For the round grenades two series of machines are used, Farwell hand presses and stripping-plate machines made by the Adaptable Moulding Machine Company, on which the moulds are hand rammed. In both cases the patterns are mounted so that cope and drag are rammed from the same face, using one pin and one pinhole in both cope and drag. On the "Farwells" a 12 in. by 12 in. snap flask is used, four castings being made in one flask, as shown in Fig. 1. No bands are used for casting, a heavy flat weight with an opening for the runner being placed on the top of the mould.

On the "Adaptable" machines cast-iron boxes are used, with eight castings in one mould, the boxes being 18 in. by 12 in. These are shown in Fig. 2. The lines showing on the pattern face are thin pieces of wood leading from the centre of the core print to the outside of the mould, and are ventways to carry the air and oil gases away. On all moulds for this class of grenade a small vent wire is pushed through the top to conduct the air from the mould, so the castings may be run very quickly, the ingate being placed on the side of the casting. The facing sand used is a mixture of equal parts of best red, yellow brass, and old floor sand, with the addition of 1-20th of the whole bulk of coal dust, the whole being well ground and mixed before using. This does away with dusting the moulds with facing, the sand coming away from the castings quite easily and leaving a very smooth skin.

The cores are shaped like a dumb-bell, one core thus being used for two castings; and in the centre of the print is a small raised piece which coincides with one on the pattern, this being done so that the core can be set by simply dropping it into the print, the raised piece preventing it from being placed further into one casting than the other

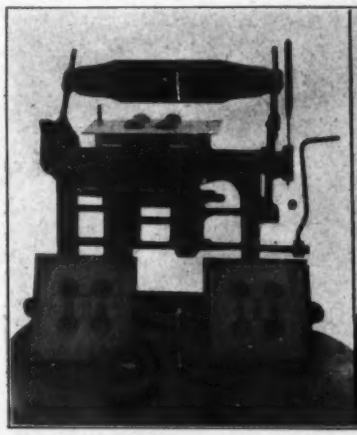


FIG. 1.—GRENADE MOULDING ON THE "FARWELL" MACHINE.

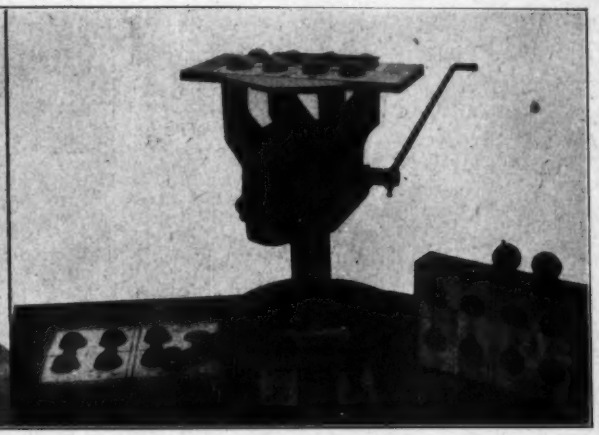


FIG. 2.—MOULDING EIGHT GRENADES ON THE "ADAPTABLE" MOULDING MACHINE.

(which would alter the weight), and doing away with the use of templates for setting. The ventway before mentioned also leads away from this part of the core.

Each core-box is made in three portions, two being the box proper, the other a dummy part. These are shown in Figs. 1 and 2, as are also the cores and the method of setting them. They are made as follows :—The bottom half is rammed with sand and the core-iron and vent-wire placed in position, then the dummy part placed in position and also rammed up. After taking away the

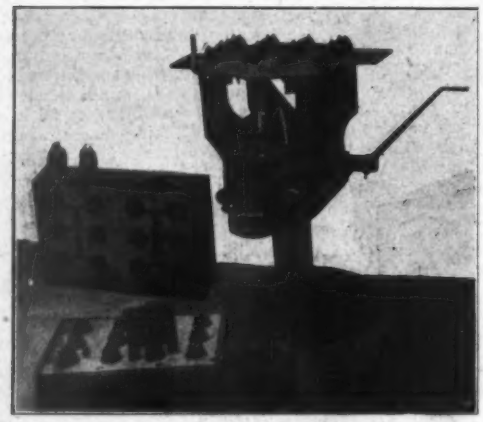


FIG. 3.—MOULDING OVAL GRENADES ON "ADAPTABLE" MACHINE.

dummy the core is left, as shown at Fig. 4, the core being given its correct shape by putting on the other part and giving it a few smart taps with a wooden mallet (Fig. 4). The vent-wire is now withdrawn, the core released from the box, and the hole made by the wire made up, as a passage for the escape of gas is formed by the small stud (see Fig. 4) on which the wire rests whilst the core is being rammed. This method gives a core that is perfect in size and shape, and does away with making the core in two halves and pasting them together. By using the first method cores could be made at about twice the rate of the pasting method. The complete core-box is shown in the photos Figs. 1 and 2, the dummy being similar to the others, but left open at the top for ramming.

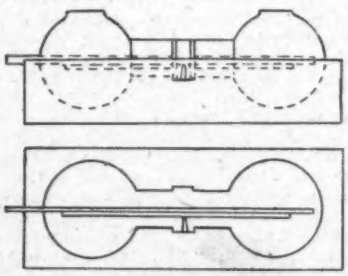


FIG. 4.—CORE-BOX FOR SPHERICAL GRENADES.

For the oval grenade the "Adaptable" machines are used and also the same type of boxes, but with 12 castings in one box. These grenades have 12 grooves running from top to bottom, and also three round the body, the latter being formed in the machine shop, so the castings have to be made on their ends, one core for each, which is set by template, as in Fig. 3, which also shows rough castings and two finished ones. To get gas away from core a wire is pushed down every print, also underneath the boxes. A vent is made through the top of the mould to conduct away air in the mould.

The core-box from which the cores are made is somewhat of a novelty (Fig. 5). It is in two halves, hinged on one side, and when closed is secured by a catch. Into one half a hole is drilled in which to place a spring, strong enough to force the box open when the catch is released. To use the box it is closed and the sand rammed through the print until the box is filled, a core wire inserted and also vented. After tapping very lightly the core-box is turned over and the catch released, allowing the box to spring open, leaving the core intact. Before using this spring the core had to be turned out on the hand, for if the box was opened on the bench the core was generally knocked over or remained fast in one half. The sands, both facing and core, are the same as for the round ones.

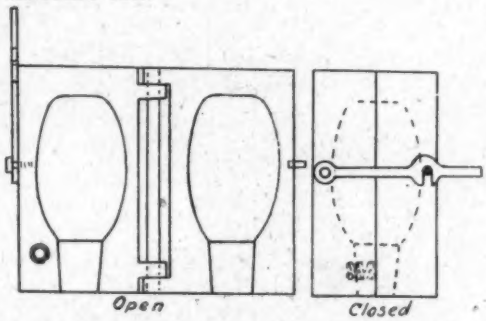


FIG. 5.—CORE-BOX FOR OVAL GRENADES.

The iron for these grenades must be close, but also easy to machine; and as they are very thin in section suitable irons must be used that will not chill on the edges which have to be machined. The following irons are used in the particular case under consideration:—1½ cwt. Staveley No. 3, 1½ cwt. Glengarnock No. 3, 2 cwt. Thorncliff No. 3, 6 cwt. good machinery scrap. As no complaints have been received in connection with this, it can be taken as being as satisfactory as any other for this class of casting generally.

TOUGHENING CHEMICAL FILTER PAPERS.—Writing in the "Chemical News," Dr. Clayton Beadle draws attention to a simple method of strengthening a filter paper so as to withstand the pressure of a filter pump, which is credited to E. J. Bevan about 30 years ago, but which might be more widely known. The paper is folded and fitted into a dry funnel in the ordinary way, and then a few drops of nitric acid of 1.42 specific gravity are allowed to fall in the apex of the paper cone. The funnel is canted and quickly rotated so as to saturate the free unsupported apex of the cone with the acid, and is then immediately rinsed out under a tap, being filled and emptied from the top repeatedly, and finally rinsed out with distilled water if the presence of tap water is undesirable. This treatment does not slow the filtering action of the paper. On the contrary, it tends to accelerate it, though treating the paper similarly all over slows the filtering very considerably, perhaps four or five times.

Some Scientific Aspects of Steel Founding*.

By W. A. Naish, A.R.S.M., A.I.M.M.

The following resumé of facts concerning steel has been compiled, not as representing new information, but as a summary for the aid of founders who are not particularly familiar with steel work.

Under the name "Steel" are now included so many varieties of iron that it is impossible to give a good definition of the term. Until the introduction of mild steel, steel was always defined as being iron containing from 0.5 per cent. to 1.5 per cent. carbon, with small quantities of other impurities, and which, when heated and quenched in water, becomes sensibly harder. Now, however, we have steels containing much less than 0.5 per cent. of carbon, and which do not sensibly harden on quenching. A definition now perhaps more accurate is "any form of iron other than malleable iron, containing 2 per cent. of carbon or less, with small amounts of other impurities."

Classification.

There are many classifications, the most general, perhaps, being "hard steel" and "mild steel," the dividing line being taken at about 0.5 per cent. carbon. The two forms pass gradually into one another, and the hardening on quenching becomes less as the percentage of carbon decreases. Another classification is "high," "medium" and "low-carbon steels." The high-carbon steels are used for tool steels, and the low-carbon as structural steels.

Another classification is based on the method of manufacture:— (*a*) Puddled steel, made from pig-iron which has not been fused, but welded up from a pasty mass; (*b*) cement steel, made from malleable iron; (*c*) crucible cast steel; (*d*) Bessemer steel; (*e*) open-hearth steel; (*f*) basic steel.

The American Institute of Mechanical Engineers in 1876 introduced the terms:—Weld iron, weld steel, ingot iron, ingot steel.

Chemical Composition of Steel.

Steel is essentially a compound of iron and carbon, other constituents being regarded as accidental impurities, except in so far as they are introduced to confer special properties.

Carbon—The carbon contents of a steel may vary between 0.1 per cent. and 1.8 per cent. or more. The grade of the steel is usually determined by the quantity of carbon present. Graphitic carbon is never present except, perhaps, occasionally in high-carbon steels. A variety of uncombined carbon known as graphitic temper carbon sometimes separates when high-carbon steels are slowly cooled. The combined carbon exists in at least two forms:— (*a*) As a definite carbide disseminated through the metal called "carbide carbon"; (*b*) distributed evenly through the mass either in combination with the whole of the iron, or in solution with it. This variety is chiefly present in hardened steel, and is called "temper carbon."

Silicon.—The general effect of this constituent is to harden and strengthen the steel, but to a much less extent than carbon. Turner says that "the increased strength due to 0.2 per cent. silicon is about 1.8 tons." Campbell states that "silicon cannot be classed among the highly injurious elements, and small quantities cannot exert a very deleterious effect, but when the percentage is very high the metal becomes very hard and brittle."

Phosphorus is universally regarded as the greatest enemy of the steelmaker. Up to 0.1 per cent. it increases the tensile strength, but if the metal is subjected to shock it is liable to break readily. The effect of phosphorus seems to be greater in higher-carbon than in low-carbon steels. It produces a typical coarsely-crystalline structure and it lowers the maximum temperature to which the steel may be heated in working.

Sulphur produces "red shortness" and gives a coarsely-crystalline fracture. The metal also tends to crack during rolling and welds badly. If manganese is present in the steel a larger quantity of sulphur is permissible.

Manganese counteracts the effect of sulphur, increases the tensile strength, but also increases the tendency to crack when suddenly cooled. Up to 1 per cent. it has little injurious effect on mild steel, but in larger quantities it tends to make the metal brittle under shock.

The effects of nickel, tungsten, chromium, etc., are briefly considered under "Special Steels" later.

The compositions of high-, medium- and low-carbon steels are as follows:—

	High carbon.	Medium carbon.	Low carbon.
	Per cent.	Per cent.	Per cent.
Carbon	1.2	0.5	0.15
Silicon	0.29	0.2	0.09
Sulphur	0.01	0.04	0.03
Phosphorus	0.01	0.04	0.03
Manganese	1.0	0.85	0.4

Methods of Steel Making.

The method of making steel directly from the ore is now obsolete except in the special case of the Stassano electric furnace.

Cementation.—The process of steel-making from malleable iron is one of cementation, and depends upon the fact that if bar iron is heated for a long time at a welding temperature in contact with carbon the latter travels into the iron and the metal becomes carburised. We have to account for two changes in the material: (*a*) the transmission of the carbon into the iron; (*b*) the formation of "blisters." There probably is a very slow diffusion of the solid carbon into the iron, but the usually accepted theory is that at the high temperature, and in the presence of excess of carbon, carbon monoxide is produced, $C+O=CO$. This penetrates into the pores of the iron, and is decomposed on contact, carbon being deposited, and carbon dioxide being produced $2CO=CO_2+O$. This carbon dioxide diffuses out, and is reconverted into carbon monoxide. At welding temperature the carbon combines wth the iron, and steel is produced. Professor Arnold has investigated the phenomenon and published his results in the "Transactions" of the Iron and Steel Institute, 1898. The "blisters" are probably due to the presence of minute specks of solid impurities, such as oxide of iron. Carbon is deposited in contact with these, carbon monoxide is evolved, and the oxide reduced, the gas attempts to diffuse, and if near the surface the metal cannot resist the pressure and a "blister" is formed.

* Read before the London Branch of the British Foundrymen's Association, February 18, 1916.

Crucible Cast Steel.—The process of making crucible cast steel is essentially one of melting, but certain chemical changes also take place. There is always some oxide of iron in the metal and air in the pot, therefore there is at first, at any rate, a basic silicate formed. As the action proceeds this becomes more and more acid. The composition of the metal may change somewhat, as it will pick up a little silicon from the pot and carbon from the fuel; also the mere fact of the metal being molten for some time will give opportunity for a slight oxidising out of carbon and silicon. The presence of manganese tends to prevent the removal of silicon by oxidising first, and thus using up the available oxygen. The result of melting, then, is almost always to increase the percentage of carbon and silicon and to reduce the manganese. The amount of sulphur also increases slightly, either from the pyrites in the clay or from the furnace gases.

Killing the Metal.—As is well known, the freshly-melted metal teems fiery and yields an unsound casting, due to evolution of gas during cooling. The "killed" metal teems quietly. According to Howe, killing probably acts chiefly by enabling the metal to absorb silicon from the walls of the crucible, thus increasing its solvent power for gas and enabling it to retain in solution during solidification the gas which it occludes when molten. The common belief is that killing expels the gas present, so that less remains to escape on pouring; but we find that silicon is rapidly absorbed during killing, and when the conditions are such that the metal cannot absorb silicon, holding the metal molten does not kill.

The production of sound castings by "medicines," automatic stirring and by presses is briefly discussed later under "Casting of Steel." The most generally used "medicines" or improvers for steel are manganese peroxide, common salt, sal-ammoniac, fluorspar, potassium chlorate, and, in the case of large ingots, aluminium and silicon.

The processes of making steel from pig-iron may next be considered.

Acid Bessemer Process.—The theory of this process is the oxidising out of the impurities by blowing air through the molten metal. The plant is well known. The removal of carbon commences immediately, also silicon is similarly removed, but in the acid process sulphur and phosphorus are not removed. This fact makes it impossible to use a phosphoric iron in this process. The percentage of silicon must be at least 2.25 to 2.5 per cent., as it is the principal source of heat during the operation; but at the same time it should not exceed 3 per cent., as the metal may become too hot and too much iron may be carried away as silicate of iron. A suitable pig would be:—Graphitic carbon, 3.42 per cent.; combined carbon, 0.46 per cent.; silicon, 2.5 per cent.; sulphur, 0.05 per cent.; phosphorus, 0.03 per cent.; manganese, 0.5 per cent.

Recarburising by means of spiegel or ferro-manganese fulfils two purposes: (1) Adding the requisite amount of carbon; (2) improving the metal by removing occluded oxygen.

Basic Bessemer Process.—As mentioned above, the acid process will not remove phosphorus. In order to do this, a basic lining is necessary, and lime is also thrown into the converter. Phosphorus is very little removed until the carbon has gone, that is, during the "after blow." The phosphorus is removed as calcium phosphate in the slag, and an important point is that the basic slag must be poured off before recarburising, or some of the phosphorus will be reduced back again, and re-enter the iron. It is the phosphorus which provides the heat of reaction in the basic process, and the silicon should be low. A suitable pig would be:—Graphitic carbon, 0.82 per cent.; combined carbon, 2.83 per cent.; silicon, 0.63 per cent.; sulphur, 0.07 per cent.; phosphorus, 2.75 per cent.; manganese, 1 per cent. The steel can be made milder than in the acid process, but it is not considered so reliable by some engineers.

As a passing reference to the modifications of the Bessemer process, such as the Clapp-Griffiths, the Tropenas, Walrand-Roberts and the Swedish, it may be said the chief difference is merely that of alteration in size and shape of the converter, the question of side *versus* bottom blowing, and fixed *versus* rotating vessels. Small converters can never become general, but at the same time there are obviously cases where their use is advantageous. There is an increased loss of 4 per cent. in side blowing, and less uniform mixing of the metal. As to fixed converters, the time is longer, as the charge must be tapped. They do not permit of bottom blowing, and it is impossible to recarburise in the converter.

Open-Hearth Process.—In this process the oxidising out of the impurities is effected by means of oxide of iron. Recarburising is effected by means of ferro-manganese or carbon (the Darby process). As in the Bessemer process, the phosphorus is not removed in the acid open-hearth. In the basic process lime is added, and the lining is of dolomite, but it is not necessary to use basic bricks above the slag line. As the source of heat is external, the amount of silicon and phosphorus is not so important as in the Bessemer process.

The modifications of the open-hearth process are chiefly mechanical. The Wellman and Campbell tilting furnaces ensure, amongst other things, quicker working. The Bertrand-Thiel process consists of working two furnaces together, nearly purifying in the "primary," and finishing off in the "secondary" furnace. The Talbot process is a continuous one, part of the finished charge being tapped and fresh pig added.

The removal of sulphur by the Saniter process is effected by bringing molten steel into contact with lime and calcium sulphide, whether in the furnace or in the ladle, the sulphur passing into the slag as calcium sulphide. Sulphur is also removed to a certain extent by the use of a mixer, which may be regarded as a reservoir for molten metal previous to steel making.

Electric Smelting.

Extravagant claims have been made for electric smelting, but there is no doubt that high-class steel can be made and cheap materials used, as phosphorus, sulphur, etc., are removed to a trace. Probably it will come into operation for refining materials, and in connection with open-hearth and Bessemer steel. Electric furnaces are used for making high-class steel from pure materials and from rail ends and scrap; for making special steels from open-hearth and Bessemer steel; for making ferro-chrome and ferro-silicon; for the direct production of steel from ore.

The high quality of the steel produced by electri- smelting is probably due to the absence of occluded gases, the absence of over-oxidation and less segregation. Steels of highest quality, equal to the best crucible steel, can be made at a lower cost. For special steels for guns it can compete with the open-hearth furnace. For ordinary rail or structural steel it is too costly unless water-power is available. It is highly recommended for refining Bessemer and open-hearth metal. If molten metal is used, the extra cost over the open-hearth is small, and is more than compensated by the low price of the materials used.

Casting of Steel.

In the casting of steel there are four defects to be considered :—

(1) *Blowholes.*—These are due to occluded gases, carbon monoxide, hydrogen and nitrogen produced from the moisture in the air and in the materials, oxygen from the air, carbon and the constituents of the air itself. These gases cannot completely escape and are mechanically entangled in the pasty metal. An approximate analysis of a gas of this nature is as follows :—Carbon dioxide, 0.48 per cent.; hydrogen, 49.8 per cent.; carbon monoxide, 48.23 per cent.; methane, 0.40 per cent.; nitrogen, 1.40 per cent.

It is a known fact that steels of practically the same composition vary greatly in hardness, tensile strength, etc., when manufactured in different ways. This may possibly be attributable to the presence of nitrogen. Nitrogen is particularly injurious to special steels. Nitrogen and oxygen tend to produce blowholes, and sometimes they produce a peculiar kind of brittleness, due to pickling. This can be removed by annealing. The deleterious effect of these gases should be more widely recognised. Information on this subject may be obtained from a paper by Walter Giesen. (Iron and Steel Institute, Carnegie Scholarship Research Memoirs, 1909.)

(2) *Piping.*—This is due to the solidification of the metal nearest the side of the mould, and its consequent contraction. The pipe is formed as an internal cavity, usually at the top of the ingot.

(3) *Segregations.*—By segregation is meant the separation of the metal into portions of different composition during solidification. Steel is not a definite chemical compound, and therefore the less fusible constituents solidify first. There is a tendency for pure, or nearly pure, iron to separate first. In ordinary ingot casting the segregation is not large. In a plate ingot 10 in. thick the carbon may vary from 0.18 per cent. at the top to 0.15 per cent. three inches from the bottom, and the phosphorus from 0.075 per cent. to 0.058 per cent. in the same limits.

(4) *Cracks.*—These are produced by the expansion of the mould and its drawing away from the metal. If not sufficiently plastic to follow, the metal will crack. The unequal contraction of the external and the internal portions of the ingot may also produce a fracture.

Prevention of Defects in Cast Steel.

Mechanical Pressure.—This involves the use of a press, such as the Whitworth or Illingsworth. In the former the contraction of the metal is followed up; it is really casting under pressure.

Agitation and Centrifugal Force is another method which has been tried.

Chemical Methods.—The two substances usually used to prevent defects are aluminium and silicon. The action of silicon is very marked, and entirely removes blowholes, the explanation probably being the same as that given under " killing " of crucible cast steel. The action of aluminium is quite as marked, but the rationale of the action is less understood. It may be due to the fact that aluminium removes oxygen, and as oxygen diminishes the solubility of the gases in iron, the aluminium may thus indirectly raise the solvent power.

Special Moulds.—The principle involved in the use of special moulds to prevent the defects mentioned is to make the lower 70 to 80 per cent. of the mould thicker, and therefore of greater heat absorptive capacity than the upper 30 per cent.

Special Steels.

There has been a great advance made of late years in the manufacture of special steels. The following notes relate to the effects of the special constituents introduced :—

Nickel Steel.—The tensile strength increases with the percentage of nickel. Thus 0.3 per cent. nickel gives a tensile strength of 31 tons, whilst with 11.4 per cent. it is 65 tons. The elastic limit increases more rapidly than the ultimate strength. Nickel steel has a high vibrating strength, and is more rigid and tough than ordinary carbon steels. The recalescence point is lower, the annealing temperature is lower, and the metal hardens when quenched from a lower temperature. It resists corrosion, and possesses a high electrical resistance. It loses its magnetism when heated, but regains it when cooled. Nickel 3.5 per cent. has about the same effect on tensile strength as 0.2 per cent. carbon. Other constituents being constant, 0.8 per cent. and from 3 to 5 per cent. nickel gives a good tool steel.

Manganese Steel.—The effect of manganese is to harden the metal as the percentage of manganese increases. Up to about 5 per cent. manganese the metal is very hard, while over 7.5 per cent. it becomes hard and tough. Hadfield's manganese steel has a tensile strength of 67 tons, and the metal is ductile. The electrical resistance is very high, and it is non-magnetisable.

Chrome Steel.—The chief property that chromium confers on steel is that of hardness; hence its use in armour plate and projectiles. Five per cent. chromium will give a tensile strength of 74 tons unannealed.

Tungsten Steel.—Tungsten makes the steel intensely hard, and this hardness is not reduced by slow cooling. Tungsten steels are not hardened by heating and quenching, hence the name, " self-hardening steels." These steels are much in favour as tool steels. An average composition is 1.5 per cent. carbon and from 6 per cent. to 9 per cent. tungsten, although lower percentages are now common. Under this heading may be mentioned a special steel the composition of which is as follows :—Carbon, 0.55 per cent.; chromium, 3.5 per cent.; tungsten, 13.5 per cent.

Molybdenum and Vanadium are used in special steels, the latter especially in some American tool steels. They have a still greater proportionate effect than those elements mentioned previously. A typical analysis of an American molybdenum steel is :—Molybdenum, 9.65 per cent.; carbon, 0.66 per cent.; manganese, 0.22 per cent.; phosphorus, 0.02 per cent.; silicon, 0.05 per cent. Many molybdenum steels have a lower percentage of Mo. From 0.5 to 3 per cent. of molybdenum in a high tungsten steel slightly increases the cutting efficiency.

Vanadium Steel.—Vanadium raises the elastic limit and tensile strength, but slightly reduces elongation; 0.2 per cent. vanadium added to a low-carbon steel raises the elastic limit and tensile strength 50 per cent. or more. This steel is valuable for engine parts and details subjected to alternating stress. It hammers and welds well. A steel containing 0.24 per cent. carbon, 0.28 per cent. vanadium, and 3.38 per cent. nickel gave the following results :—Elastic limit, 50.3 tons; tensile strength, 68.2 tons; elongation, 17 per cent.

It must be pointed out that the foregoing figures are general and are much affected by the percentage of carbon and by the heat treatment.

Hardening of Steel.

When a steel containing more than about 0.2 per cent. carbon is heated to redness and quenched it becomes hard. The degree of hardness depends on the rapidity of the cooling, temperature of cooling and percentage of carbon. The changes observable are :—Pure iron heated to about 900 deg. C. and

cooled slowly shows three distinct retardations, viz., at 825 deg. C. (Ar_3); 720 deg. C. (Ar_2); and 650 deg. C. (Ar_1). If much carbon is present there is only one point discernible, viz., at 670 deg. C. (Ar_1). If iron is heated three corresponding points are got, about 30 deg. C. above the Ar points, namely, Ac_1, Ac_2, and Ac_3. The retardation at Ar_1 is accompanied by a change in the condition of the carbon from hardening carbon as it exists in hardened steels to cement carbon (Fe_3C), which is present in normal and annealed steels. To convert cement carbon into hardening carbon it is necessary to heat above the critical Ac_1.

If the steel is heated above Ac_1 (700 deg. C. for 1.2 per cent. steel) and quenched, the carbon is retained as hardening carbon. When a steel is heated to Ac_1 and quickly or slowly cooled, the finest grain it is capable of assuming is produced. If heated above Ac_1 the grain becomes coarser and coarser. The best temperature to quench from is that temperature which gives the finest grain and the greatest strength, and this depends on the percentage of carbon.

Annealing.

The object of annealing is to diminish the abnormal qualities the metal acquires through hardening and mechanical working. The metal should be annealed by heating to the Ac_1 critical temperature, and keeping at that temperature a sufficient time to change a certain amount of the hardening carbon into cement carbon or the hard into the soft allotropic variety of iron. It is immaterial whether it is quickly or slowly cooled. The heating should be slow, and the steel throughout the operation should be shut off practically from the air. The time occupied in actual practice is variable, and whilst there can be no doubt that excessive annealing does no good, and may do harm, a good proportion of the unsatisfactory steel castings is accounted for by erring on the other side.

The typical structure of a normalised steel of 0.5 per cent. carbon consists of ferrite and pearlite. (Pearlite is Fe_3C. in intimate association with Fe and contains 0.9 per cent. carbon.) The amount of each constituent depends on the percentage of carbon. The structure is typical of a mild steel, which after being heated to full redness is allowed to cool in the air. A saturated steel contains 0.9 per cent. carbon, and the structure is all pearlite. As the percentage of carbon increases beyond this point, a new constituent appears, viz., cementite, Fe_3C., which is typical of super-saturated steels.

In a hardened steel there occurs a new constituent, hardenite, accompanied by ferrite in mild steel, and cementite in super-saturated steels. Hardenite is probably pearlite altered by heating and quenching. If a steel is suddenly quenched from 1,000 deg. C. the typical needle structure of martensite is got.

Annealed steels show the granular pearlite altered into parallel layers. This banded structure is true pearlite and is typical of slowly-cooled steels.

Defects Produced by Hardening.

Water Cracks.—These are the direct result of enormous stresses produced by contraction. The only remedy is to exercise the greatest care and to have a good quality steel. The steel should be low in phosphorus and manganese; 0.025 per cent. phosphorus is permissible, 0.4 to 0.5 per cent. manganese in mild steel, and 0.2 per cent. manganese in 1 per cent. carbon steels.

The *whole* of the tool should be at a uniform temperature, and the temperature should be the correct one for the percentage of carbon present.

Special Methods of Hardening.

The Barium Chloride Bath is used for taps, etc. The bath is heated to 1,200 deg. C. by gas, and the tool is soaked for a few minutes only, so as to heat up the edges. The tool should then be withdrawn and cooled either in air or in an oil bath.

Electric Furnace methods employ as the heating medium barium chloride for high-speed steels, barium chloride and potassium chloride for carbon steels, and sodium chloride and potassium chloride for lower temperatures. The current is alternating, and iron electrodes are used.

The table given below may be interesting to show the effect of annealing and hardening and tempering on gun steels of different carbon contents :—

Carbon.	Unannealed.		Annealed.	
	Tensile strength.	Elongation.	Tensile strength.	Elongation.
Per cent.	Tons.	Per cent.	Tons.	Per cent.
0.37	38	8.2	36.7	21.8
0.5	44.4	2.0	44.0	12.0

Carbon.	Annealed.			Hardened and tempered.		
	Tensile strength	Elastic limit.	Elongation.	Tensile strength	Elastic limit.	Elongation.
Per cent.	Tons.	Tons.	Per cent.	Tons.	Tons.	Per cent.
0.35	34.4	17.6	27.0	48.9	29.1	16.5

Case Hardening.

The ordinary methods of case-hardening are too well known to need description, but perhaps one or two points may be of interest.

The best carburising steels are those containing from 0.1 to 0.2 per cent. carbon. Manganese has the tendency to make the carburising surface brittle. The outer skin will usually come up to about 0.9 per cent. carbon. As a general rule, anneal after carbonising to destroy crystallisation in the core. The limit for the requisite temperature during this operation is about 925 deg. C. Carbon begins to penetrate at about 700 deg. C.

There are many special case-hardening mixtures. Guillet used 60 parts of wood charcoal to 40 of barium carbonate. Heathcote mentions wood charcoal soaked in a 5 per cent. solution of sodium carbonate.

The annealing of the castings should be at a cherry red. To ensure refining of grain, the heavy sections will require a longer time for annealing, but they may be cooled quickly if high-tensile strength and elastic limit is required.

Discussion.

Mr. E. M. Boote referred to the author's statement regarding the solid diffusion of carbon into iron, remarking that he thought that suggestion had now been discounted by authorities on the subject of carburising.

A Member said that in regard to annealing there were a lot of low-carbon steel castings made without annealing. The electric furnace had one great advantage in that it could produce metal at a higher temperature than other furnaces. The difficulty with low-carbon steels (say, 0.2 per cent. C) was to get the metal hot enough to pour light castings. The speaker expressed some criticism of the author's remarks on the influence of various constituents in high-speed steel.

Mr. H. G. Barrett referred to the question of cracking and the necessity of removing the mould to enable the casting to cool without cracking.

Mr. J. Stone recounted an experiment in which the core of the mould was made up with sawdust and Mansfield sand, blacking and core gum. Where brackets occurred in the mould channels of ashes were put. On the question of melting, he had secured a good output by melting in one pot and pre-heating pots in two more furnaces; by this means 10 or 12 pots a day could be got—150-lb. pots holding, say, 100 lbs. of metal. The first heat took longer, but the second or third melt was got in 1¼ hours. When melting steel punchings and scrap, the start required 2 to 3 hours. He also referred to the tempering of knife blades, and stated that the same good results had not been obtained in London as in Sheffield, even by the same men.

A Member remarked that the so-called rustless cutlery, containing 13 per cent. chromium and 0.6 per cent. carbon, had been quite successfully produced in Newcastle-on-Tyne.

Mr. H. Slater said that where blowholes occurred in a casting and not in a test bar from the same metal the fault was in the moulding. A hard metal, like white iron or steel, did not flow like grey iron. He had poured a certain casting with no riser and had got blowholes in it; a riser helped to overcome the trouble, but the casting was drawn in the riser. All the lugs on the casting but one were vented, and all but this one were sound, the unvented one being short-run. Bad venting was the cause of much trouble, as it caused pressure of air against the flow of metal and resulted in blowholes.

Mr. Bartlett remarked that the addition of steel to grey iron frequently resulted in blowholes; but the greater the heat of the metal the fewer the blowholes. Cylinders cast in semi-steel he had found were generally better run from the top round the core.

After some further discussion the meeting closed with a hearty vote of thanks to the lecturer.

Shells and Shell-Like Castings.

In the course of a Paper on the "Manufacture of Shells and Shell-like Castings," read before the Sheffield Branch of the British Foundrymen's Association on February 18, Mr. John T. Goodwin (foundry manager, Sheepbridge Coal and Iron Company, Limited) remarked that the manufacture of shells for filling with high-explosives or for shrapnel purposes and which were in contact with the explosion which ejected them from the gun, was an entirely different problem to the manufacture of those which were ejected otherwise. There had been considerable discussion as to why cast-iron shells should not be used for either of the above purposes; and he was of the opinion there was a great deal of prejudice which prevented their use. He believed it possible to obtain a mixture which would give the necessary tensile strength and allow the walls of the shell to be reduced and give a lighter shell. To overcome the bursting effects of the "blow-back" he suggested corrugating of the interior, at an angle giving a larger sectional area. The shell, upon explosion, would thus break along the lines of least resistance by following the angle of the corrugations and break up into more effective pieces than if it had straight sides. These castings could be cast with great accuracy, even to the limits specified for machining. The machining could be reduced and the output increased if the body and nose were accepted unmachined. The main objection to this was that the hard skin of the casting would injure the gun barrel; but as these castings would be annealed and sand-blasted to a polish, this defect would disappear. There was also the question of unequal thickness of the shell walls. After experimenting in the methods of manufacture this difficulty was overcome and a limit of thicknesses error in the shell walls of 1/50 in. was obtained. If it were possible for cast-iron shells to be accepted there would be no difficulty in obtaining an output of 4-in. or 6-in. shells at the rate of 200,000 per week.

The manufacture of "pipe specials" made with green sand cores was next described and illustrated. These included a series of types of shell patterns suitable for various pipe bends and collars. These were made with strickles and board to the required shape; an inside core was first struck up and allowed to dry, then coated with varnish. A further layer was then struck on, the thickness of which was equal to the desired thickness of the pipe. It was allowed to set, and afterwards trimmed off and, when necessary, flanges fitted. The internal plaster core, together with the board, was used as the turning-over board when making an iron pattern of this plaster cast. There was, said the lecturer, great saving in this method of moulding, as it dispensed with the use of core plates and irons and the drying in core stoves. The delay through having to dry these moulds was often a very serious item, especially should the casting be required urgently and eventually prove to be a "waster." With this principle, a casting of, say, a 4-in. bend might be made and ready for delivery in six hours or less, according to circumstances. It was not advisable that this method of moulding should be adopted for any but standard types of castings, off which large quantities were continually being ordered.

Turning to the casting of subway plates, or castings for the purpose of lining tunnels and shafts, Mr. Goodwin said for large quantities an iron pattern was preferable, though the Sheepbridge Company had made successfully as many as 600 plates off a well-made wood pattern. The pattern was fitted up on a turning-over board. Only the side flanges were one with the pattern, the end flanges being made of mahogany and worked loose. The bottom box was placed on the ramming board and rammed up in the usual way and was then turned over and bedded on to the floor. The board was then removed and facing sand riddled on to the joint. Afterwards the top box part was put on and rammed up and finished, then lifted off, the pattern removed, mould finished and cores placed in position and the box closed up. There was, therefore, nothing abnormal in the manufacture of these plates. Under these conditions two moulders, one lad and a labourer could make 20 per day. Casting and stripping were included in this operation. There was, of course, much to be said in favour of placing such repetition work as this on to a moulding machine. It would certainly reduce the labour in ramming up, but he did not see much saving afterwards in handling.

Mr. Goodwin, in conclusion, described the method of machining the castings. The type of machine required was extremely expensive, and in the earlier designs the tools were a failure, as the makers did not appreciate the difficulties of cutting at a high speed through the hard skin, and the jar on the cutter heads caused by the tool passing the bolt holes. To save the machines, which were continually breaking down, a much lower feed had to be adopted, with consequent reduction in output. The later machines were designed much heavier and speeds increased, the tool maker having gained his experience at the foundryman's expense.

Coke Consumption in the Cupola.

By M. E. Gallon.

The question of coke consumption in the cupola will well repay any foundryman for devoting a little time to its consideration; for, although cupola practice is better now than ever it was, there are hundreds of foundries whose cupola bills are very much higher than they ought to be.

The cupola-man is not scientific; therefore it would be worse than useless to start and split hairs over decimal points; so that in quoting round figures, as the writer will do as far as possible, there is no desire to avoid nicety of measurement, but only an attempt to make the meaning so clear that the cupola-man unaccustomed to figures will understand.

The specific heat of cast iron is 0.130, its melting point is 1,960 deg. F., and its casting temperature, say, 2,500 deg. F.; therefore, theoretically, 1 cwt. of coke ought to melt 37 cwts. of metal, or 60¾ lbs. of coke ought to melt 1 ton of metal. But a lot of heat is lost up the cupola stack and by radiation in the walls of the furnace, for which at least 40 per cent. must be allowed, so that with ideal conditions in practice, quoting round figures, 85 lbs. of coke ought to melt 1 ton of metal, or 1 cwt. of coke ought to melt 26 cwts. of metal, and this is the goal for which we ought to continually strive.

Let it be clearly understood that saving of coke at the expense of quality of metal is not aimed at; the quality of iron is always the paramount consideration. But if the great waste of coke that goes on from year to year in our foundries can be prevented, then an important economy will be accomplished.

Reference may here be made to a question raised by the writer before the Newcastle Branch of the British Foundrymen's Association, viz., "With two cupolas melting at the same rate per sq. in. of area at the melting zone, is it possible for one cupola to use more coke than the other per ton of metal melted?" Let the two cupolas cited be termed "A" and "B." Cupola "A" is 28 in. dia., cupola "B" is 52 in. dia. In round figures the area of "A" at the melting zone is 616 sq. in. and that of "B" 2,124 sq. in. "A" melts 2½ tons per hour and "B" 7¼ tons per hour. These figures work out at 8.181 lbs. for "A" and 8.178 lbs. for "B" per sq. in. of area at the melting zone; so that for practical purposes it is near enough to say that both cupolas are melting at the same rate, i.e., a little over 8 lbs. per sq. in. of area at the melting zone.

But now comes the great question of how much coke each cupola is using to melt one ton of metal. The founder owning cupola "A" uses 1 cwt of coke to 14 cwts of metal, while the figures given for cupola "B" are 1¼ cwt. of coke for 30 cwts. of metal, or 1 cwt. of coke to 24 cwts. of metal. Assuming, then, that these figures are correct (for the writer is certain of one and does not doubt the other), there is apparently a great waste of coke in cupola "A." Therefore we may enquire the reason why.

First, examining the blast arrangement of both cupolas, it is found the air service is equally good in both, which is proved by the fact that both cupolas are practically melting at the same rate. If, then, the air service is not at fault there is only one other place to look for the reason of the great difference of coke ratios in the two furnaces, and that is up the stack. There it is found that the height from the tuyeres to the charging door in cupola "A" is 8 ft. and in cupola "B" 12 ft.

To understand the working of a cupola it is necessary to know something of the gases that perform the work of reducing the iron. These are two in number—carbon monoxide (CO) and carbon dioxide (CO_2). Quoting from Bell, "If the carbon unit reaches the tuyeres it is burnt there to the condition of carbon monoxide (CO), giving off, therefore, 2,400 heat units; if the same unit of carbon in the form of carbon monoxide (CO) reduces oxide of iron it becomes carbon dioxide (CO_2), and if it escapes as such it will have generated a further amount of heat, namely, 5,600 heat units—together 8,000 heat units." Bell speaks of these gases in connection with the reduction of iron ore, but they have a direct bearing on cupola working, for they are the same gases which are produced in melting pig-iron in the cupola.

It will be readily seen that the more carbon dioxide (CO_2) that can be formed the greater will be the heating power exercised among the stock in the furnace, and this is exactly what takes place in the larger and longer cupola. In furnace "B" the gases have 50 per cent. longer journey to travel, which allows a correspondingly larger amount of the carbon-dioxide to be formed; hence the stock in "B" is heated up to a much greater temperature than in furnace "A," so that when the stock reaches the melting zone in furnace "B" it is almost in a liquid state and takes very little more heat to reduce it to that state. But in furnace "A" the conditions are quite different, for the gases have only 8 ft. to travel against 12 ft. in furnace "B"; hence the stock in furnace "A" reaches the melting zone at a very much lower temperature than in furnace "B"; and here is where the great difference in coke consumption comes in.

If both furnaces are going to melt at the same rate per sq. in. of area, then furnace "A" must hasten, for it has much more work to do at the melting zone than "B." To do this work it needs more heat. This it gets by using more coke and, of course, more blast to consume this extra coke. So it is seen that two cupolas of different sizes can melt at the same rate per sq. in. of area at the melting zone, but the smaller one of the two will have to use a great deal more coke than the other; also more h.p. will be required per ton of metal melted.

The question arises as to what would have been the result had both cupolas been the same height from the tuyeres to the charging door. There seems to be little doubt that the coke consumption in both cupolas would have been as near as the melting rates. The writer visited a small foundry which had a cupola of smaller diameter than cupola "A" but of the same height to the charging door. The cupola-man was following out the old method of guess measurement, and said he was using half-a-cwt. of coke to 5 cwts. of metal, but as the metal was only coming down at a third of the rate that it should do, the charges would seem to have been more like half-a-cwt. of coke to 8 cwts. of metal. The writer advised that next cast the metal and coke should be weighed in the proportion of 1 of coke to 12 of metal, or in charges of a quarter-cwt. of coke to 3 cwts. of metal, the weight of the

charges of iron to be increased at succeeding casts, keeping the weight of coke constant until the highest melting efficiency of the cupola was reached. This was done, and the ratio was found to be the same as in cupola "A," viz., 1 of coke to 14 of metal.

So there seems to be little doubt that cupolas of the same height will melt at the same rate per sq. in. of area at the melting zone with the same consumption of coke per ton of metal melted, always providing the air service is equally good; and if economy of coke is aimed at it is beyond doubt that the higher the cupola can conveniently be made the better. But great care should be taken with cupolas under 3 ft. diameter, for unless properly constructed the stock will hang, and this should be avoided at all costs. Cupolas of over 3 ft. dia. ought to give little or no trouble.

The best method of testing the capability of any cupola is to charge it first in the proportion of 12 of metal to 1 of coke, and each succeeding cast increase the charges of metal, keeping the charge of coke the same until it is seen that the metal is dulling off at the tap hole. When that occurs the limit is reached. Lighter charges of iron may be put on, but if heavier charges are attempted trouble will probably be experienced.

Quick Production of Carbon Steels.

By J. Peers.

The author first desires to make a comparison between the Siemens-Martin and Bessemer processes of steel-making. Taking for example an average acid Siemens-Martin furnace of 25-tons capacity, it is safe to infer that under the best working conditions a 25-ton heat is produced, and if eleven heats cover the weekly output of a double shift—that is, a night-and-day turn—it is considered a good result for the week's work. This means approximately 275 tons of steel. With a Bessemer converted of 12-tons capacity a night-and-day shift will turn out under the same favourable conditions 17 heats per shift, that is 34 heats of 12 tons for each 24 hours. In ordinary times, when five and a half days are worked, there is thus the startling difference in figures, with no increase of labour, between 2,112 tons as the weekly output of a Bessemer converter and 275 tons as that of a Siemens-Martin furnace—a margin on the side of the Bessemer of 1,837 tons.

It must be very evident there are serious grounds for reflection in this surplus of production, and it must also be borne in mind the labour expended is not so great in the Bessemer process.

Carbon Control.

Without doubt, the Siemens-Martin process has held sway over the Bessemer by reason of carbon control. But carbon control does not receive its fair share of study. Under ordinary conditions the methods employed to get actual percentages of carbon in samples and drillings in the Siemens-Martin process appear to result largely in wasted energy, when simpler and effective methods can be used in the converter process. As the resultant steel blown in the converter generally approximates to a uniform mixture, we have a basis to work from, the calculation being, say :—

C.C.	Si.	Mn.	S.	P.
0.04	0.02	Trace	0.06	0.06

Suppose, for example, a carbon content of 0.55 C.C. is required in the steel. By adding a 7-lb. bag of crushed anthracite coal that has been put through a ¼in. mesh and put in a brown-paper bag, 0.1 carbon is added to the steel; therefore, if 0.55 is required, five bags of the crushed anthracite will be used.

The coal should not be used in any haphazard manner, and the bag must be thrown into the steel as it is being poured out of the converter into the ladle. It must also be thrown in from a position sufficiently elevated to allow the coal on the bursting of the bag to spread itself freely. It must further be borne in mind that as the same amount of metal is not always assured from the cupola the coal should be judged according to amount of steel, the slag mark on a ladle being a good guide. Although one bag of 7-lb. capacity will give 0.1 per cent. C. in a 12-ton blow it would be bad practice to use a 14-lb. bag to get double; it is much better to use the coal in 7-lb. lots, as shop practice varies, and a full 12-ton blow is not always registered. By using anthracite in this way a great scope is obtained in carbon steels for construction. Beyond 0.9 per cent. C. it would be impossible to gauge the effects of the addition, as after 0.6 per cent. C. the iron is not so hungry for carbon. However, the figures will show clearly that with the remarkable difference in tonnage between the two processes, and the scope afforded by the use of anthracite coal, a better return will be assured on the week's output from the converter.

In the Tropenas process for steel castings, to raise the carbon content cast iron is introduced. This is a dangerous method, because very often the labourers are burnt, and also the quality of the castings is affected by reason of the extra phosphorus and sulphur added. If a 3-ton Tropenas converter is in use a 3-lb. bag of crushed anthracite will add approximately 0.1 per cent. C., and as the carbon is required to be higher more bags can be used. This process can be conducted with a proficiency that will surprise most steelmakers.

Alloying Additions.

Alloying additions are added apart from this coal addition, and are mostly added in a warmed solid state. In the Bessemer converter this addition of alloys in the solid state does not have the detrimental effects it does in the open-hearth process, because Bessemer steel is hotter and can use much more energy in melting the alloys. In the Siemens-Martin process the alloy should be added in liquid form, which would do much to obviate "ghost lines" in ingots. Alloying in the solid state has a tendency to create these "ghost lines," but I am confident that they would not appear if all alloys were melted instead of using up the energy of the molten steel.

Under the conditions of works practice the Bessemer converter must have the preference if the anthracite additions are used carefully, as all Siemens-Martin steel is liable to "ghost lines" because of adding the alloys in a solid state.

DURABLE LEATHER.—Complaints are at present very common regarding the lack of durability in the leather now tanned under stress of war, owing to the urgency of military demands. An important economy in foundry and iron and steel works' operations generally can be made by using a tough, durable and specially-tanned leather, and in this connection our attention is drawn to the old-established firm of Messrs. John Muir & Son, tanners, of Beith, Scotland, who have successfully specialised in the work. This is evidenced by the very general use of their hard leathers, etc., by the leading firms of the United Kingdom for years back. The firm employs progressive and scientific methods of tanning which give a product well worthy of attention.

New Open-Hearth Furnace Ports.

According to an article by K. Kneiper, in "Stahl und Eisen," a gas port introduced by Zdanowicz, of Resicza, has been found to act well in several Austrian and Hungarian works, and to be easily installed, the work being completed during a week-end. Fig 1. is a sketch of a furnace port with the device ("cage") in position, the irregular line 5—6 representing the contour of the corroded port. The originally sharp edge at 3 has been worn away, as shown, by the gas in changing its course from the vertical flue to the slanting inlet. To prepare the port for the cage, the vertical flue is cut away from A to B, and an arched lining, 1, 2, 3, 4, is put in. (The portion above B was arched from the outset.) Recesses are cut in the front wall at A and B to correspond with the ports in the cage, which latter is got ready for placing in position (except that the rear wall D D_1 was not mounted). The cage—which for a 35-ton furnace weighs nearly 3 tons—is lowered into place by means of a crane and well bedded in mortar, to make a close joint

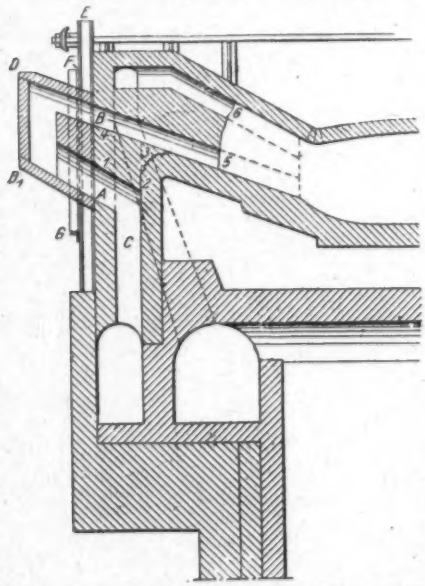


FIG. 1. SECTION OF OPEN-HEARTH FURNACE PORT WITH CAGES.

between cage and port. It is preferably secured by suspending it from the top of the vertical end girder E, and bolting the angle irons F and G to this girder (Figs. 1 and 2). Any uneven parts of the flues are next smoothed down through the open end D D_1, and this opening being sealed up, the furnace is ready to resume working. If operations are carried on at both ends of the furnace, all the four cages necessary can be installed in 12 hours, so that the furnace need not be stopped for more than a whole day.

Fig. 3 shows a cage ready to be placed in position. Assuming the port to have been worn down to a length of 40 in., the length of the flues when the cage is in position will be about 8½ ft., which is longer than those in many furnaces, even when quite new.

The conditions inside the furnace are favourably modified, inasmuch as the ports no longer project into the heated portion of the furnace, and are therefore well protected against further corrosion. Assuming that proper attention has been bestowed on the fire-bridge, the gas is conducted effectively and the furnace works normally. After putting in

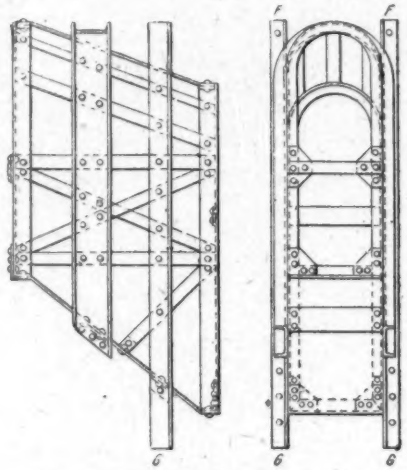


FIG. 2.—IRON FRAMEWORK OF CAGE.

the cages the 34-ton furnace at Resicza has been run, on different occasions, for 202 and for 328 charges before being laid off for other repairs.

First among the advantages of the device is the fact that the ironwork of the four cages is a non-recurring outlay. An empty cage for a 34-ton furnace weighs 16 cwts., or 3¼ tons the set of four, say 3½ tons of ironwork, with bolts, etc., included, the cost normally being £50. The brickwork for the four cages weighs 8 tons, the cost being £16. This brickwork does not need renewing completely when the cages are replaced, but only repairing, so that more than 50 per cent. of the brickwork is recovered each time, an amount at least equivalent to what would be required for repairing the port in ordinary circumstances. The cost of labour in laying the brickwork is £10 10s., and the royalty to the patentee £12 10s., making the total cost per set of cages about £45. Assuming that 250 charges can be worked before replacing the cages, the increased output from the furnace will be 8,500 tons, so that the cost of the cages per ton of this steel amounts to only 1¼d., or, including other repairs to the chamber and lining, a fraction under 9d. per ton. The repairs in the ordinary course, without the use of cages, would be not less than 1s. 6d. per ton, so that in a six months' run there is a saving of

FIG. 3.—CAGE READY FOR ATTACHING.

some £335, apart from the £30 it would cost to reheat the furnace from the cold.

Another important advantage claimed is the increased annual output from the furnace. The ordinary stoppages for small repairs, including heating up again, take at least ten days each, or about 14 days in the year. Taking the average number of charges per day as four, the cages allow an increased production, in the 34-ton furnace, of about 1,900 tons per annum, or approximately 5 per cent. of the normal capacity.

The benefits claimed for the cages may be summed up as follows:—(1) Maintaining proper guidance for the gases without stopping the furnace, which ordinarily would have to be laid off for repairing the ports; (2) increasing the working life of the arch; (3) lessening the cost of relining; (4) enabling the flues on any existing furnace to be lengthened; (5) saving coal for heating up; (6) improving the annual production of the furnace; (7) easy manipulation of the extension members in consequence of the extensive sub-division of the total weight of material employed.

FIG. 1.—BOTTOM PLATE FOR 32 INGOT MOULDS (BACK QUADRANT FILLED WITH BRICKS).

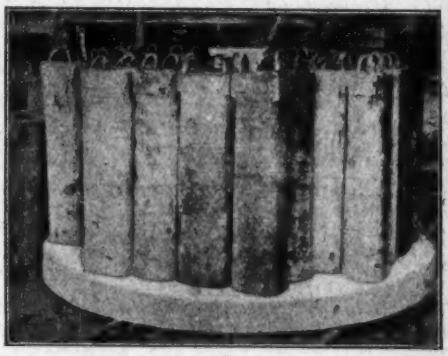


FIG. 2.—SHOWING 32 INGOT MOULDS ASSEMBLED ON PLATE.

Bottom Plates for Pouring Ingots.

In a recent issue of "The Iron Age," Mr. Robt. H. Irons, general superintendent of the Central Iron and Steel Company, of Harrisburg, Pa., U.S.A., indicates the results obtained by the use of an improved type of bottom plate for pouring steel ingots, designed to secure uniform filling of all the moulds. He points out that in the manufacture of plates, especially the boiler and firebox grades, small surface defects in the ingots are responsible for similar defects in the plates with attending rejection by inspectors. At the works named the entire ingot output is bottom-poured. Investigation revealed the fact that when the steel rose quietly and uniformly in the moulds the ingot had a good surface, but when the steel was "wild," invariable ill-effects were noticed. It was further observed that the wildness was frequently due to one mould filling faster than the rest and then surging into another mould. The customary practice in bottom pouring consists of arranging the moulds on the bottom plate on radial grooves. This of necessity involves unequal distances for the metal to travel in reaching each mould from the central fountain. A design of bottom plate was adopted in which each mould was fed from the fountain by a runner of the same length and of the same number of turns. This insures equal resistance to each mould, and experience shows that uniform filling of all moulds takes place under these conditions. Fig. 2 shows 32 moulds assembled on a plate and illustrates the compactness which this method permits and the tonnage that can be poured in this way. It should be particularly noted that, owing to the increased tonnage poured per plate, the sprue loss is a smaller percentage than with plates having radial grooves.

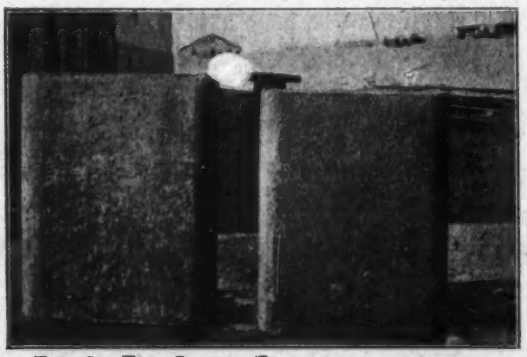


FIG. 3.—TWO INGOTS (LEFT-HAND ONE POURED ON RADIAL GROOVED PLATE AND RIGHT-HAND ONE ON IMPROVED PLATE).

BRITISH v. GERMAN WORKMEN.—At a recent meeting of the North-East Coast Institution of Engineers and Shipbuilders, Sir Charles Parsons, F.R.S., who occupied the chair, in a discussion observed that an Englishman was better than a German, man for man. There was no doubt about that. About ten years ago his firm took out comparative figures of the work done by various classes of workmen in building a 1,000-kilowatt turbine. They had full access at that period to the books of Messrs. Brown, Boveri, of Baden, Switzerland, a firm associated with them pretty closely then. They compared the work of British workmen with the work of German patternmakers, founders, coppersmiths, machinemen, fitters and erectors. They found that the amount of work done by the Englishman was 8 compared with the Germans 5 per hour. Of course, the Englishman got higher wages and worked shorter hours than did the Germans. The total wage bill of the English-made article was 17 per cent. higher than that made in German Switzerland. The only item which was not taken into account in that period was that there were then no old-age pensions in this country, and there were in German Switzerland, where the workmen were all of German origin.

Canteen Construction and Equipment.

A Memorandum has been issued by the Ministry of Munitions giving the conclusions of the Health of Munition Workers' Committee on the subject of canteen construction and equipment. The site for a canteen, it is recommended, should, if possible, have a pleasant open outlook and southern aspect, and should be easy of access for the workers. With high buildings adjoining and mess rooms looking out upon blank walls not many yards distant, the canteen may prove unattractive and its success be to a great extent impaired. The canteen should, if practicable, be placed where water, gas, and electric mains are adjacent, as well as drainage capable of carrying off the discharge of soil and rainwater pipes and of sinks and lavatory wastes.

Plans are given with the Memorandum showing canteens suitable for 400 and 280 diners. As to whether the building should be of temporary or permanent construction, during the war there is much to be said for the erection of a temporary building, mainly on the ground of cost, rapidity of erection, and the smaller demands made upon labour. In normal times the case for the permanent building is a strong one, but at the present time it is considered that for canteen purposes the temporary building should be the type adopted. The floors generally should be of concrete, finished with a granolithic face. This type of floor is smooth, hard, durable, and impervious, and is easily washed down after meals. Wherever possible, advantage should be taken of using local material to save railway carriage, cartage, &c.

The canteen or dining hall, being the principal apartment, should be arranged with the most convenient methods of egress and ingress for the workers and with direct approach to the serving counter. Barriers in front of the counters are advisable to allow of each diner obtaining his or her food in the order of arrival, so that there may be no possibility of crowding or pushing. Adequate gangways or passage-ways for each diner to proceed to the dining tables without interruption to other diners are essential. The kitchen should be situated as centrally as possible with regard to the dining room, which it should adjoin. The wash-up or scullery should open out of the kitchen and should abut immediately upon the main dining hall. A counter or shelf with communicating hatch should be provided to admit of dirty crockery being handed direct to the hot water sinks. In addition to the sinks in the scullery, such accommodation is also required in the kitchen for the use of the cook in the preparation of food. The sinks should be supplied with hot water from an independent boiler, which should be placed as near as practicable to the sinks. The sanitary accommodation for the canteen should preferably be situated in an isolated block of buildings adjacent to the canteen, but the requirements in this respect depend upon the sanitary accommodation already existing in adjoining buildings.

Ample window space (with a large proportion of the windows opening) is desirable for light and ventilation, and in no case should the total glass area of the windows be less than one-tenth of the floor area of the various rooms in which they occur. The fanlights for casement windows should be hinged at the bottom and fall inwards. Glazed cheeks or gussets should be provided to admit of continuous ventilation, and at the same time prevent down draft. All casement windows should be made to open for use in warm weather, and to flush the rooms with air after the principal meal. Louvre ventilators under the roof or in turrets provide ventilation for the main mess room. A simple cord attachment to wooden flaps should be provided to admit of these ventilators being closed during cold or windy weather. The kitchen should be provided with a continuous louvre ventilator. It is desirable, where electric or other power is available, that an exhaust fan should be placed in the kitchen to extract the heat and steam from the kitchen and scullery, and incidentally assist in the general ventilation of the dining rooms. Larders should face north and have nearly half the glass omitted in the window panes and perforated zinc panels substituted to provide suitable ventilated storage for perishable food.

The cost of galvanised corrugated sheet iron for external covering is now almost prohibitive, and alternatives are ungalvanised corrugated sheets (painted) or roofing felts. These felts are usually laid on the boarding with a lapped joint and patent cement supplied by the makers, the sheets being then secured with galvanised clout or large flat-headed nails. Light asbestos slates also provide a satisfactory, although somewhat heavier, roof covering. A large variety of materials are available for the external coverings of the walls, amongst which may be mentioned feather-edged weather boarding (treated with creosote), ungalvanised painted sheet iron, plaster finished in cement, secured to the wood framing by expanded metal, asbestos slates, or other materials. Internally, plaster and cement on expanded metal, asbestos sheets (the joint covered by a small fillet), match boarding, or various other materials can be used above the dado. The dado should, however, be somewhat stronger; ¾ in. match boarding is suitable. Thin sheet iron (painted) has also been used; or linoleum on flat-jointed boarding provides a suitable dado, and is easily cleaned. The interior of the building should present a clean and cheerful appearance, and distempers of a fairly light tint are preferable.

Central heating by radiators or hot-water pipes would, no doubt, provide the most satisfactory means of heating the building. The cost, however, of such a heating installation adds considerably to the initial cost of the whole scheme. Where central heating is not provided, use may be made of an independent stove, standing on the concrete floor, the stove pipe being carried up through the roof. The steps to be taken for the prevention and extinction of fires should be fully considered. Where electricity is available it is, no doubt, the most satisfactory means of artificial illumination, otherwise gas should be used. For the means of cooking food for canteen purposes attention may be confined to electricity, gas, coal and steam. Electricity has not hitherto been very largely used, but in any case where the power can easily be provided it is worthy of consideration. Where gas in sufficient quantity is available, gas cooking is usually preferred on account of cleanliness, efficiency, and saving of labour. Coal is suitable in districts where it is obtainable at cheap prices, or where gas is unobtainable. As the adoption of steam cooking necessitates the installation of an expensive plant, this method need not be considered unless a special supply of steam is available.

The Memorandum concludes with a detailed list of articles required for the catering equipment. As prices vary considerably, no estimates are given; but, speaking generally, it is considered that the cost of inclusive equipment would be, approximately, 32s. per head for 100 persons, 21s. 6d. for 500, and 20s. 9d. for 1,000.

Alloys of Chromium, Copper and Nickel.

In a Paper presented before the American Institute of Metals, the alloys of chromium, copper and nickel were discussed by D. F. McFarland and O. E. Harder, as follows:—

During the process of development of the acid-resisting alloy described by Professor S. W. Parr,* it was found desirable to make a somewhat systematic study of the binary alloys of chromium-nickel, chromium-copper, and copper-nickel, together with the ternary alloys of the three metals. This Paper is intended to present a summary of the more important results obtained. The binary alloys have all been studied by previous investigators and the freezing-point curves fairly satisfactorily worked out for chromium-nickel and copper-nickel. The curve for chromium-copper, however, is still incomplete and the published data is of doubtful value.

The copper-nickel alloys are all solid solutions and present a continuous freezing-point curve. Chromium-nickel alloys have two series of solid solutions but form what is said to be a eutectic at about 42 per cent. nickel. Copper and chromium are said to form eutectiferous alloys at each end of the series but do not form homogeneous mixtures through a wide range of composition. The various writers disagree as to the limits through which alloying takes place between the two metals and place the solubility of chromium in copper at from 0.5 per cent. to 10 per cent.

Some of the binary alloys are of commercial importance, including Monel metal, Constantan, nickel coinage alloy, among the copper-nickel series; Nichrome and similar resistance alloys in the chromium-nickel series; and a few chromium-copper alloys of rather limited composition and use.

In the present work attention has been directed mainly to a study of the physical, mechanical, and chemical properties of the alloys, rather than to the working out of the diagram of thermal equilibrium. In all, 21 binary and 30 ternary alloys have been prepared with the proportions of the metals varying by 10 per cent. intervals. It was expected that all of the possible 66 alloys would be made and studied, but the unusual difficulties involved in the melting and casting of some of the high-chromium members of the series have prevented the making of some of them.

The alloys were prepared by melting the metals in "Crescent" safety crucibles in a Hoskins electric furnace of the carbon-plate resistor type. In some cases a temperature of over 1,600 degrees C. was required to give a sufficiently fluid mixture. The charge used weighed 300 grammes. The metals were protected from oxidation and other changes by a cover of cryolite and by the atmosphere of carbon monoxide which was maintained in the furnace. The molten alloy was cast in asbestos-lined iron moulds, ¾-in. in diameter, and 8 in. long, which had been heated to bright redness and packed in powdered silica. The metal thus cast cooled very slowly.

Analyses made of each specimen showed considerable variation from the calculated composition, (see Table No. I.), indicating changes which had occurred in the melting process. Chromium was the metal most affected in the melting, the loss amounting in some cases to several per cent. This was partly due to the ease with which chromium is oxidized, but was also partly due to its inability to enter alloys with copper and nickel in large percentages. The highest chromium content obtained in chromium-copper alloys was

Table I.—*Composition of Alloys of Chromium, Nickel and Copper.*

	Calculated composition.						Composition by analysis.		
	Atomic per cent.			Weight per cent.			Weight per cent.		
No.	Cu.	Cr.	Ni.	Cu.	Cr.	Ni.	Cu.	Cr.	Ni.
1	100	—	—	100.00	—	—	—	—	—
2	90	—	10	90.71	—	9.29	90.84	—	9.06
3	80	—	20	81.27	—	18.73	81.07	—	18.76
4	70	—	30	71.65	—	28.35	71.16	—	28.46
5	60	—	40	61.90	—	38.10	61.63	—	38.25
6	50	—	50	52.00	—	48.00	48.96	—	49.90
7	40	—	60	41.94	—	58.06	69.13	—	30.59
8	30	—	70	31.70	—	68.30	41.14	—	58.27
9	20	—	80	21.31	—	78.69	20.65	—	79.35
10	10	—	90	10.74	—	89.26	10.57	—	88.90
11	—	—	100	—	—	100.00	—	—	99.66
12	90	10	—	91.68	9.32	—	94.20	6.08	—
13	80	10	10	82.12	8.40	9.48	84.30	7.79	9.28
14	70	10	20	72.43	8.45	19.12	74.63	8.25	16.05
15	60	10	30	62.58	8.53	28.89	66.32	10.63	22.64
16	50	10	40	52.57	8.60	38.83	54.71	15.94	29.35
17	40	10	50	42.40	8.67	48.93	42.56	10.13	48.00
18	30	10	60	32.05	8.75	59.20	32.69	13.97	54.16
19	20	10	70	21.55	8.81	69.64	20.85	11.80	66.25
20	10	10	80	10.87	8.89	80.24	11.83	11.90	*76.27
21	—	10	90	—	8.96	91.04	—	19.37	78.99
22	80	20	—	83.02	16.98	—	87.93	13.15	—
23	70	20	10	73.22	17.12	9.66	80.58	10.56	9.38
24	60	20	20	63.28	17.25	19.47	66.92	13.62	19.20
25	50	20	30	53.16	17.40	29.44	56.30	14.56	29.24
26	40	20	40	42.88	17.54	39.58	44.08	19.30	36.34
27	30	20	50	32.41	17.69	49.90	36.70	15.99	*47.31
28	20	20	60	21.80	17.83	60.37	22.20	19.86	57.36
29	10	20	70	10.99	17.98	71.03	10.88	19.64	68.62
30	—	20	80	—	18.14	81.86	—	21.52	76.95
31	70	30	—	74.05	25.95	—	89.82	9.89	—
32	60	30	10	63.99	26.17	9.84	73.63	17.68	8.55
33	50	30	20	53.77	26.38	19.85	59.62	22.00	19.48
34	40	30	30	43.37	26.61	30.02	48.70	25.10	29.52
35	30	30	40	32.79	26.84	40.37	33.76	29.46	*36.78
36	20	30	50	22.05	27.06	50.89	22.58	28.10	48.42
37	10	30	60	11.12	27.29	61.59	10.90	29.70	58.12
38	—	30	70	—	27.52	72.48	—	28.44	*71.56
39	60	40	—	64.71	35.29	—	Not prepared.		
40	50	40	10	54.38	35.58	10.04	70.57	19.93	8.99
41	40	40	20	43.86	35.89	20.25	54.16	*31.63	14.21
42	30	40	30	33.17	36.20	30.63	33.60	38.16	26.78
43	20	40	40	22.31	36.50	41.10	22.68	41.32	34.60
44	10	40	50	11.25	36.82	51.93	11.02	43.30	46.46
45	—	40	60	—	37.14	62.86	—	44.93	56.55
46	50	50	—	55.20	44.80	—	Not prepared.		
47	40	50	10	44.38	45.37	10.25	Not prepared.		
48	30	50	20	33.57	45.76	20.67	28.42	54.92	17.12
49	20	50	30	22.58	46.16	31.26	24.12	47.54	26.28
50	10	50	40	11.39	46.56	42.05	Not analysed.		
51	—	50	50	—	46.96	53.04	—	57.40	41.66
52	40	60	—	44.89	55.11	—	—	—	—
53	30	60	10	33.96	55.59	10.45	—	—	—
54	20	60	20	22.85	56.06	21.09	—	—	—
55	10	60	30	11.53	56.56	31.91	Not analysed.		
56	—	60	40	—	57.07	42.93	Not analysed.		

* Determined by difference.

13.15 per cent., while in all alloys of this series containing more than 6 per cent. of chromium, there was a separation of chromium and a non-homogeneous structure. Nickel was also lost somewhat during the fusion of alloys high in this constituent.

In order to throw light upon the ability of chromium and copper to alloy when mixed in equal proportions, a mixture containing 50 per cent. of each of the two metals was heated to above the melting point, thoroughly mixed, and

* Foundry Trade Journal, December, 1915, p. 662.

held in the molten condition for some time. It was allowed to cool very slowly and the solid mass was sawed in two and examined. A well defined line of separation could be seen into two layers, one consisting of chromium containing some copper, the other of copper containing chromium.

Physical and Mechanical Properties.

Colour.—As would be expected, the colour varies with the proportion of copper, but the copper colour is not as persistent as the colours of chromium and nickel, and is lost long before the proportion of copper reaches 50 per cent. Alloys higher in copper show the greater tendency to tarnish in the air of the laboratory, while those higher in nickel and chromium are very little and only very slowly affected. Alloys high in nickel give more porous castings and are liable to have blowholes.

Specific Gravity.—The specific gravity measurements were made at 25 degrees C. and gave results varying from 8.92 to 7.89, decreasing with increase of chromium.

Hardness.—The hardness tests were made with a Brinell testing machine using a 3,000 kg. load. The specimens tested were about 20 mm. in diameter with parallel, smooth faces. The hardness numbers varied from that of pure copper to that of tool steel and increased with increase of chromium. The alloys high in chromium are too hard to be cut with an ordinary hack saw and in some cases approach the hardness of high-speed steel after hardening.

Tensile Strength.—The ultimate tensile strength of the 18 alloys tested varied from 7,449 to 56,255 lbs. per sq. in. The measurements were made with an Olsen universal, screw-power testing machine, of 10,000 lbs. capacity, using short test pieces 3 to 4 in. long, having a diameter of 0.3 ins. for a length of 2 in., and threaded at the ends so that they could be screwed into ½-in. grips. Elongations were measured with a Ewing extensometer. The results are shown in Table II.

Reduction in Area and Elongations.—These were small in all cases. The alloys did not show well defined yield points or elastic limits but showed a gradual flattening of the stress deformation curve. The curves were similar to those for cast iron.

Modulus of Elasticity.—Calculation of the modulus of elasticity gave results varying from 15,000,000 to more than 40,000,000, or from one-half to one and a half times that for steel.

Corrosion Tests.—One of the chief interests in this series of alloys lies in its possibilities for furnishing material of high resistance to corrosion. In order to determine the ability of the various alloys to resist corrosion an extended series of tests was made, subjecting each specimen successively to the action of several of the more important corroding agents under standardized conditions. The corroding agents used were normal solutions of nitric, hydrochloric and sulphuric acids, normal solutions of sodium and ammonium hydroxides, and of sodium chloride and pure molten fatty acids. The results for the different corroding agents may be summarised as follows:—(*a*) The amount of corrosion is not proportional to the strength of the acid or base. (The word strength is used in the chemical sense, denoting concentration of H or OH ions in the solution). (*b*) A triangular system of plotting the corrosions in relation to the composition of the specimens as determined by analysis, shows fairly well defined areas which are highly resistant to corrosion. (*c*) Not only are the alloys in the region approximating the composition of the alloy developed by Professor Parr highly non-corrodible, but others also have shown equally good resistance. In no case, however, does the acid resistance of the simple ternary alloys equal that of the best Parr alloy. (*d*) Generally, the ternary alloys are less corroded than the related binary alloys, although there are some marked exceptions to this rule.

TABLE II.—*Hardness, Specific Gravity, Modulus of Elasticity, Tensile Strength and Kind of Casting.*

No.	Brinell Hardness Number.	Specific Gravity 25°C.	Modulus of Elasticity lbs. per sq. in.	Ultimate Tensile Strength	Kind of Casting.
1	—	—	—	—	Good
2	Broken in test	8.56	—	—	Good
3	Cracked in test	8.76	—	—	Medium
4	Cracked in test	8.92	—	—	Blow holes in places
5	Specimen too small	8.76	—	—	Blow holes in places
6	Specimen too small	8.78	—	—	Good
7	98	8.53	—	—	Good
8	—	—	—	—	Casting had blow holes
9	—	—	—	—	Blow holes all through
10	—	—	—	—	Blow holes in places
11	Broken in test	8.69	—	—	Large crystals and small blow holes
12	68	8.78	—	—	Good
13	86	8.57	—	—	Sound
14	103	8.81	18,000,000	19,978	Sound
15	143	8.72	—	—	Sound
16	161	8.75	—	—	Sound
17	163	8.62	—	23,833	Fair
18	—	—	—	—	Small blow holes
19	—	—	—	—	Fair, had blow holes
20	—	—	—	—	Fair, had blow holes
21	—	—	—	—	Large blow holes
22	69	8.60	—	—	Sound
23	82	8.71	—	—	Good
24	89	8.34 (?)	20,000,000	17,521	Good
25	99	8.62	7,000,000	14,880	Good
26	156	8.52	12,000,000	14,802	Very good
27	175	8.54	—	—	Sound
28	179	8.50	—	56,253	Sound
29	126	8.48	7,000,000	19,846	Sound. Specimen was small
30	—	—	—	—	Large blow holes
31	68	8.47	—	—	Medium
32	117	8.55	—	—	Small, but sound
33	116	8.49	17,000,000	22,650	Excellent. Some conc. of Cr. at top of casting
34	126	8.42	20,000,000	25,768	Good
35	148	8.34	16,300,000	38,734	Excellent
36	170	8.34	23,700,000	32,654	Excellent
37	163	8.36	22,000,000	29,630	Excellent
28	181	8.23	15,800,000	36,958	Good
39	Not prepared ...	—	—	—	—
40	121	8.33	—	—	Small, but sound
41	116	8.38	—	—	Good
42	131	8.14	26,400,000	7,449	Excellent
43	156	8.12	—	—	Excellent
44	163	8.13	16,300,000	29,587	Excellent
45	147 (?) Cracked in test	8.14	—	—	Good
46	Not prepared ...	—	—	—	—
47	Not prepared ...	—	—	—	—
48	107	8.24	57,000,000	33,842	Excellent
49	—	—	43,200,000	22,336	Sound
50	202	7.89	—	—	Good
51	179	7.95	48,000,000	37,200	Good
55	228	—	—	—	Sound
56	179	—	—	—	Sound

Nickel is especially dissolved from the alloys by nitric acid. In the chromium-nickel series the loss decreases as the percentage of chromium rises. All of the metals are somewhat attacked by hydrochloric acid but chromium is especially affected. In sulphuric acid the results are of about the same order of magnitude as in nitric acid although they are not strictly parallel. The losses in sodium

hydroxide are, in general, low. Copper and nickel are appreciably dissolved, while chromium is hardly affected. The action of ammonium hydroxide is more marked on most of the alloys than that of sodium hydroxide. The alloys which best resist its action are near the nickel corner of the triangle and on the chromium side. The copper-chromium alloys and the copper-rich ternary alloys show a selective removal of copper. The tests in fatty acids were made at 85 degrees C. and at 105 degrees C. The greatest losses found were in the copper-rich alloys. The results suggest that copper-nickel alloys might give better satisfaction for use with fatty acids than plain copper, especially if a little chromium were added to the alloys.

General Conclusions.

From the present information it seems that the alloys of chromium-copper-nickel which show possibilities of becoming of commercial value are limited to certain rather well defined ranges of composition. A triangular diagram shows this very well. In the nickel-rich corner of the diagram the alloys have very large polyhedral crystals, coarse texture, and usually develop blow-holes on casting. There is a possibility that the texture and casting qualities of the alloys in this region can be greatly improved by the addition of a fourth metal and by the use of deoxidizing and degasifying agents, as has been done by Professor Parr.

The alloys containing high percentages of chromium have such high melting points and are so difficult to prepare that unless they find special and important applications there is little chance that they may be manufactured commercially. Their extreme hardness is also a factor which must be considered, both as a possible advantage and as a probable great disadvantage in the working of the alloys.

The alloys containing large percentages of copper with chromium show such marked segregation that they do not machine well and their mechanical properties are not good.

Fortunately, alloys in the restricted region which seems to promise best from the mechanical and physical standpoints, show also, as a general rule, the best resistance to corrosion in practically all of the solvents used.

SUGGESTED RESEARCH ON CHISEL STEELS.—In the course of the discussion on a Paper by Mr. H. Fowler, entitled "Chisels," presented at the annual meeting of the Institution of Mechanical Engineers, Sir R. A. Hadfield said he noted that Mr. Fowler was an advocate of carbon steel; but he (the speaker) suggested it was possible that greatly improved practice might be obtained by using an alloy steel. A chisel should last as long as possible and do as much work as possible, and the speaker was positive that the question of improving the life and work of the chisel would be aided by testing a few special steels. It would be interesting if the Institution of Mechanical Engineers would form a small sub-committee to take this matter up; this would lead to considerable improvement in practice. As an example, the speaker would suggest a chromium steel, say a carbon steel with a similar carbon content to that mentioned by the author, or a lower carbon content—0.55 or 0.6 per cent. carbon—to which should be added 1 per cent. of chromium. He imagined that a chisel made of such an alloy would have a longer life, which would be a great advantage in large engineering shops.

Reclamation of Magnalium from Turnings.

In a paper read before the American Institute of Metals, Mr. John Coulson remarked that the use of magnalium for finished castings had increased to such an extent that the recovery of the metal from the turnings had become an important factor. He gave the following short account of an investigation of the problem, and outlined successful means of acquiring reliable metal from the turnings, without suffering more than 1 or 2 per cent. loss in the melting:—

It is well known, of course, that magnalium metal is an alloy of aluminium and magnesium, having a specific gravity less than that of pure aluminium. Magnalium containing from 5 to 10 per cent. of magnesium has very desirable physcial characteristics, and castings made from it can be machined without difficulty. The extensive use of this metal, by the Westinghouse Company, in the manufacture of automobile parts and electrical apparatus, brought about the problem of recovering the metal from the great quantity of turnings resulting from the finished castings. Ordinary methods of melting down scrap metal could not be applied in the case of magnalium, on account of the rapidity with which the turnings oxidised.

Oxidation of finely-divided magnalium progresses more rapidly and violently than in the case of aluminium, and it is well known that freshly-cut aluminium is covered with an oxide film immediately on exposure to the air. The temperature of a twisted mass of bare aluminium wire can be raised above the melting point without becoming diffused, the wire may sag, but when cooled will be found intact. The jacket of Al_2O_3 prevents the wire from melting into a solid molten mass, and becomes even stronger under comparatively high temperatures. Therefore, some process of agitating the melted material must be applied, in order to break up the oxide films, thus forcing the molten material to diffuse. Fluxes composed of chlorides and fluorides of the alkaline earths have been used with some success. Such fluxes when hot dissolve a certain amount of the oxide, and their gassing throws about the globules of molten metal, inviting them to coalesce. The use of cryolite in the production of aluminium has long been known and is quite commonly used for smothering aluminium chips. The cryolite is first melted into a viscous state, then the scrap aluminium fed into the crucible and pushed under the surface of the flux, which forms a protective layer of cryolite on top and keeps the chips from further oxidation. The foundry has used this method for some time in melting magnalium turnings and the recovery for clean material varied from 60 to 90 per cent. Usually, equal weights of cryolite and turnings were added to the melting pot.

The use of cryolite as a flux is objectionable, however, since it attacks silicon or graphite crucibles vigorously, and iron pots cannot be used when pure metal is required. The desirability to avoid it as a flux led to extensive experiments to find if it was possible to melt the turnings, without appreciable loss, in the presence of some inert or reducing gas. As the work progressed, small, special, air-tight, cylindrical shells were built according as the method of applying the gas demanded. The cavity inside the shell admitted a Gooch crucible which held the charges of turnings to be melted. Tight-fitting caps, pierced with gas pipes, closed the ends of the cylinder. The whole fitted inside an electric furnace, which had a limiting temperature of 1,200 deg.

C. With everything in place, and after the gas had been washing out the system for five or ten minutes, the electric current was turned on and the temperature raised to 900 deg. C. Of the numerous gases used throughout the work, hydrogen gave the best results. Tests were made to see if forcing the gas through the charge as in the Bessemer process would break up and diffuse the molten globules, but the results were inferior to those in the case where the gas was admitted through the pipe overhead. With the downward flow the loss was about 10 per cent. The loss always appeared in the form of fine white powder, and on examination of this residue it was found that nitrides were formed. A strong odour of ammonia was given off when the residue came in contact with water. The vigorous evolution of this gas indicated that nitrogen was occluded in some way, and most likely in the pores of the turnings, since great care had been taken to free the hydrogen used of all contamination.

The next step was to free the turnings of all foreign matter and occluded air, replacing it by some inoffensive fluxing agent, and common salt NaCl served this purpose very well, as will be seen.

Magnalium Physical Tests.

History of pieces.	United stress lbs. per sq. in.	Yield point lbs. per sq. in.	Elastic limit lbs. per sq. in.	Per cent. elong. in 2 in.	Per cent. reduction.
New Material—					
Lab. 95% Al. 5% Mg....	24,500	11,000	6,000	9.2	13.4
,, ,, ...	23,100	11,000	5,000	8.7	11.5
Shop ,, ...	21,700	19,800	17,200	1.8	1.6
,, ,, ...	24,550	16,250	11,500	4.0	3.9
,, ,, ...	19,630	17,000	9,700	2.3	1.6
Lab. Al.	13,150	7,500	4,000	33.0	52.0
Reclaimed Turnings—					
Lab. No flux	12,100	11,000	600	—	—
,, ,, ...	13,750	13,750	10,000	—	—
,, Hydrogen wash	13,870	13,800	7,200	—	—
,, Under cryolite...	20,100	17,500	10,750	—	—
,, ,, ...	11,950	11,950	9,500	—	—
,, No flux, 45 min. wait	19,300	15,250	800	1.5	3.5
Shop. Under cryolite	15,000	13,000	12,500	—	—
,, ,, ...	14,500	12,500	12,500	—	—
,, ,, ...	21,750	21,750	16,500	—	—
,, ,, ...	19,500	19,500	14,500	—	—
,, ,, ...	13,750	13,750	10,000	—	—
,, ,, ...	13,900	13,500	7,200	—	—
Reclaimed Turnings deoxidised on Second Melting—					
Lab. ½% Al. Mn. ...	23,000	20,250	12,500	1.3	3.9
,, 1½% Met. Cal. ...	24,750	16,000	9,500	2.0	3.9
,, 1% Met. Cal. ...	24,370	18,000	8,500	2.0	5.9
,, ½% Cal. Al. Silicide ...	24,430	19,000	8,500	3.7	7.8

The turnings were boiled for a few minutes in a 4 per cent. salt solution; this was poured off, taking with it the objectionable scum which would otherwise cohere to the turnings if they were scooped out. Further experiments were tried, using the apparatus described above, and charges of the turnings still moist with the salt solution, but the results were not as good as we had expected. In every case a small amount of turnings remained intact and on top of the metal which had united. A new apparatus was constructed so that gas pressure from above forced the melted turnings through holes in the bottom of the crucible and into a receptacle underneath. In this way it was possible to recover about 92 per cent. of the charge, but to use this method on a large scale appears difficult.

It was thought possible to melt the turnings in an open crucible after they had been boiled in a solution of slightly fluxing salt; experiment proved this method to be a success. The turnings, after being washed thoroughly in benzine, were boiled in a salt solution which was poured off just before feeding them into the crucible. The crucible fitted snugly through a hole in the cover of an ordinary blast crucible furnace, and before starting operation it was heated to a temperature of 900 deg. C. The damp turnings were then fed into the hot crucible and by mechanical means forced to coalesce as they melted. Each addition of turnings was thoroughly puddled until the mass again became uniformly viscous. Melts from 1 to 6 lbs. were handled in this manner, using different salts and combinations of salts for the bath. A 4 per cent. solution of NaCl gave very good results; the recovery being 96.2 per cent.

The application of this puddling process in melting the turnings in the open crucible without preliminary treatment in the salt solution also proved satisfactory. To start the melt a small pellet of magnalium was first reduced to a molten state in the bottom of the crucible; this permitted puddling to proceed on the first application of the turnings, thus smothering them immediately. The average loss from a number of melts, about 6 lbs. each, was 6 per cent.

It was found desirable to let the charge stand in the hot crucible for 10 or 15 mins., after the last puddling operation. This gave the oxide time to rise to the surface, where it was held while the clean metal was poured from underneath. The dross-like mass that remained in the crucible, after pouring, contained some good metal, but this was separated from the oxide by adding a small quantity of $CaCl_2$ and stirring the whole vigorously. If the metal began to burn, as was the case if the temperature got much above 800 deg. C., a little cryolite (powdered) stopped the action. Drawing the charge off through a hole in the bottom of the crucible, in place of pouring from the top, alleviated the danger of the charge burning up, and permitted the work to go on without having to displace the crucible.

The metal recovered from the turnings can hardly be expected to be as good as the original magnalium. It is practically impossible to avoid the entanglement of some oxide in the melting. However, the physical characteristics of the reclaimed metal can be much improved, if not restored completely, by treatment or the introduction of a deoxidising agent. Test pieces were poured from melts of new and reclaimed metal, which experienced different treatment, or had added to them a small quantity of deoxidising metal. The results of the physical characteristics of a few of these pieces are tabulated below, and show what may be expected from the various combinations and treatment of the metal. As will be noticed, the magnalium made in the laboratory, and indicated by the first set of results, is much superior to the shop metal from which the turnings come. Therefore, the characteristics of the reclaimed metal from the turnings are not likely to excel those of the original magnalium.

In the foundry this method of procedure has been applied with success, the loss from a 200-lb. charge being about 1 per cent. Here the recovered metal is poured in the form of large pellets, and later treated before making it into castings. From examination of the tables of physical tests it will be seen that the introduction of a deoxidising agent brings the physical characteristics of the old metal up to that of the original shop material. The addition of 1 per cent. of metallic calcium, or ½ per cent. of calcium-aluminium-silicide is quite sufficient to restore the reclaimed metal to its original physical state.

Methods of Preparing Turnings for Packing.

A Paper on methods of handling metal turnings with special regard to the best ways of preparing them for packing, read before the Verein Deutscher Ingenieure by R. Philipp, states that as they occupy a volume out of proportion with their weight, serious efforts have been made to prepare the turnings at the plant for economic transport. Jones and Lamson, for example, provided on one of their turret lathes an arrangement for breaking up the turning as it originates. This device did not prove practical. Another attempt was to arrange the cutting itself in such a manner as to prevent the formation of long shavings. This may be done by giving the tool a peculiar shape such as that of a spoon, which prevents the cutting from coming out in a smooth ribbon, prevents it also from twisting, and forces it to run in a plane. This gives the turning bends which with many kinds of steel make it brittle. This process has only a very limited application. A similar proposal was to set the cutting edge of the tool at right-angles to the axis of rotation. For heavy work and for many kinds of steel this is not adaptable because it increases the power consumption and does not prevent the formation of long, strong turnings. An attempt was made to destroy the elasticity of the turnings by annealing and hardening them to make them brittle, but this process proved to be too expensive.

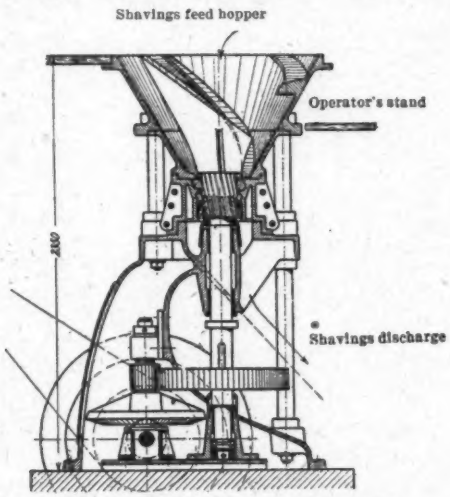


FIG. 1.—METAL TURNINGS CRUSHER.

Attempts to cut the turnings themselves likewise did not prove successful, because thin ones can be cut only with very sharp tools, and unless the tools are quite sharp the turnings begin to bend and clog the machinery. Further, cutting requires rapid and uniform feeding of the material, which is not always possible, and granted that these difficulties have been overcome, the output even at the high speed of cutting will be quite small.

Another process which is used to a certain extent by briquetting concerns consists in allowing the turnings to get rusted. This makes them somewhat brittle, so that they can be broken up in a rolling mill or coal crusher. Before, however, they can be sent to the briquetting presses they must be passed through a screen so as to eliminate large lumps and pieces of turnings which might injure the presses. One of the disadvantages of this process is that the metal, being partly rusted, is of lower quality. Hammer mills can also be used for this purpose, but a disadvantage lies in the fact that the turnings are apt to roll about the rollers to such an extent that a hammer and chisel are required to get them away. The application of scrapers does not entirely eliminate this difficulty, besides it is necessary for various reasons to make one of the rolls adjustable, which complicates the use of scrapers. Henschel & Son, the German locomotive builders, use a kind of rolling mill consisting of two geared rollers, both rollers being of the same diameter and mesh from the top outward. At the outer sides of the rollers are located sharp deflectors. One of the advantages of this construction is that it can handle large bales of turnings because the rolling breaks up the bales. On the other hand, however, this construction did not prevent the turnings from twisting all about the rolls, even though the deflector could be made very strong and could be placed quite close to the rigidly held rolls.

The Lauchhammer process is to bale the turnings,

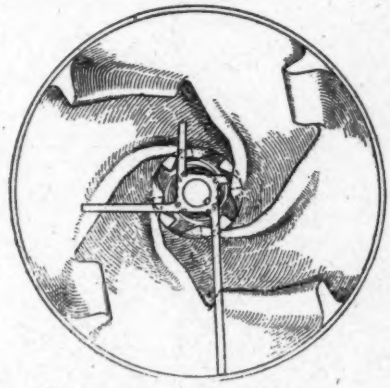


FIG. 2.—FEEDING HOPPER.

which must be in this case mixed with a certain amount of thin sheet-iron pieces and wire. The baling press consists in this case of a large box with four movable holes. After this box has been filled with turnings by means of a lifting magnet, the cover is mechanically forced on, and then first one of the side holes and next two more touching it are gradually forced in. The press consumes about 175 h.p.; 25 h.p. for forcing on the cover, 50 h.p. to move the first side hole, and 100 h.p. to force in the other two holes in contact with the first one. Six bales can be made in this way per hour. In order, however, that they should maintain their shape the bottom of the box must be covered with sheet iron or wire; then the turnings come in the middle and the top is again covered with sheet iron or wire. In machine shops this process is therefore not applicable, since there is no sheet iron or wire waste available, and the space required and the cost of operation are prohibitive.

The Henschel turnings breaker is shown in Fig. 1, while Fig. 2 shows the feeding hopper of the same machine. Tough turnings tend to wrap themselves around the rolls, and this property has been made use of here. The roll of peculiar shape rotates in

a funnel which is provided with spirally located guides, forming channels as they go downward. Ribs on the roller gradually force the turnings into the passage, where they are more and more compressed and shifted outward. By an appropriate formation of the ribs in the funnel and on the roll the turnings are uniformly distributed through all the channels over the entire cross-section of the roll. With, say, 30 r.p.m. of the roll with 8 ribs in the funnel and 20 on the roll itself, 4,800 cuts are made per minute. To this must be added that by being compressed in the channels the turnings are broken to pieces; there is practically no actual cutting, which is necessary only in the case of very tough turnings or pieces of wire and sheet metal. Because of the very low velocity of the rolls—20 to 25 r.p.m.—which are at most 8 in. diameter, there are no violent blows, and this reduces the work of the apparatus. The power consumption varies quite materially. It was found that the average power consumption of the larger units for an output of 5,500 to 6,600 lbs. per hr. was only 13 kw. The largest output obtainable from one machine was 7,700 lbs. of manganese copper in 25 minutes, which was obtained with the machine driven by an electric motor rotated at 25 h.p. The cost of breaking up the turnings is approximately 1s. per ton.

Seger Cones.

The scale of fusibility established by Seger has not only found wide application in the ceramic industry, but Seger cones are also used to a considerable extent in metallurgical work. The phenomenon of the fusion of a fusible tell-tale is a simple one, and, moreover, proceeds slowly, like the changes in a ceramic body. This presents an advantage over a number of appliances of greater precision, which furnish instantaneous indications that are really more exact, but whose interpretation entails greater skill.

The fusible tell-tales, according to an article translated from "La Céramique" by "The British Clayworker," are based on the employment of the same raw materials as are used in the manufacture of the pottery ware, admixed together in variable proportions in such a way as to obtain a suitable degree of fusibility.

The ruling idea in the production of fusible tell-tales, or Seger cones, is the employment of mixtures the constituents of which are in such relative proportions that molecular mixtures are formed. The first scale of cones, described in 1885, contained 36 numbers. The first three numbers consist of a silicate containing potash and lime in the molecular proportion 0.3 : 0.7, associated with alumina and ferric oxide. The ratio of alumina to lime is constant, and so is the acidity, but the ratio between the alumina and the ferric oxide is subject to variation, the fusibility being diminished by replacing part of the ferric oxide by alumina.

The molecular formula of cone No. 1 is: $0.3K_2O$, $0.7CaO$, $0.2Fe_2O_3$, $4SiO_2$, $3Al_2O_3$. It is obtained by the aid of four ingredients: felspar which provides the alumina and the alkalis, marble which furnishes the lime, quartz which completes the acidity, and ferric oxide. The quantities of these materials (assumed to be pure) are: Felspar 83.55 parts, marble 35.00, quartz 66.00, and ferric oxide 16.00 parts.

To obtain the succeeding numbers 0.1 molecule of ferric oxide is replaced by 0.1 molecule of alumina; that is to say, the molecule of ferric oxide weighing 112 and that of alumina 102, 10.2 of alumina are substituted for 11.2 of ferric oxide. In No. 3, only 0.5 of a molecule is replaced.

Cone No.	2.	3.
Felspar	83.55	83.55
Marble	35.00	35.00
Quartz	60 00	57.00
Ferric Oxide	8.00	4.00
Decanted Kaolin	12.95	19.43

The object of introducing kaolin is to supply the deficiency of alumina and silica.

Starting with No. 4, ferric oxide is no longer used, and, to lessen the fusibility, $0.1Al_2O_3$ and $1SiO_2$, that is to say, 0.1 molecule of kaolinite is added to the molecular formula of cone 4, viz., $0.3K_2O$, $0.7CaO$, $0.5Al_2O_3$, $4SiO_2$. By proceeding in this way we obtain for cone 10, for instance, the formula: $0.3K_2O$, $0.7CaO$, $1Al_2O_3$, $10SiO_2$.

Mixtures corresponding to these cones are obtained by using the following quantities :—

Cone No.	11.	12.	13.	14.
Felspar	83.55	83.55	83.55	83.55
Marble	35.00	35.00	35.00	35.00
Quartz	252.00	300.00	348.00	396.00
Kaolin	116.55	142.45	168.35	194.25

Cones Nos. 15, 16, and 17 are prepared on similar lines, by adding to each in succession $0.3Al_2O_3$, $3SiO_2$; and cones 18, 19, and 20, by adding $0.4Al_2O_3$, $4SiO_2$. This gives for their composition :—

Cone No.	15.	16.	17.	18.	19.	20.
Felspar ..	83.55	83.55	83.55	83.55	83.55	83.55
Marble ..	35.00	35.00	35.00	35.00	35.00	35.00
Quartz ..	468.00	468.00	468.00	468.00	468.00	468.00
Decanted Kaolin	233.10	271.95	310.80	362.60	414.40	466.20

It may be mentioned that—apart from the first members of the series, which exhibit variations in consequence of substitutions—from No. 4, each cone differs from the one preceding merely by the addition of decanted kaolin, of which 0.1 molecule is taken at first, then 0.2, 0.3, and 0.4 molecule in succession.

The manufacture of these tell-tales would be an easy matter if there were at disposal natural substances of the theoretical composition exacted by the formulæ. Nature has not provided such compounds, but, nevertheless, some of them can be found sufficiently pure to allow the traces of extraneous substances present to be neglected. The raw materials used by Seger are :—Swedish felspar, decanted Zettlitz kaolin, quartz, and Carrara marble. These materials contain :—

—	Felspar.	Decanted Kaolin.	Quartz.	Marble.
Silica	64.32	46.87	98.53	1.00
Alumina	19.41	38.56	1.04	0.12
Ferric Oxide	0.14	0.83	0.04	..
Lime	traces	traces	..	54.93
Magnesia	0.35	traces	..	0.21
Potash	12.90	1.06	..	..
Soda	2.10	..	..	..
Loss at red heat ..	0.57	12.73	..	..
Carbon Dioxide ..	..	..	..	43.76

The Weighing Problem in Shell Manufacture.

In practice it has been found that the chief danger attendant upon any speeding up process applied to shell production is inaccuracy, not in work that can be checked by the micrometer or gauge, but in the *weight* of the shells. To those who have made a study of weighing problems it will be obvious that the beam scale, *i.e.*, an equal-armed weighing instrument the pans of which are below the beam, is not the best type of balance for shell-weighing in the case of all smaller types of shells, such as 4.5 H.E., 18-pounder H.E., etc., for two reasons. The beam scale does not indicate the *amount* of error, and the time required by a sensitive beam to "settle" or vibrate is liable to be so curtailed during a rush of work that the result is inaccurate—a "catch" weighing. A sensitive beam scale such as any of those sold by the leading scale manufacturers as entitled to rank under Class B., and fitted with continuous knife-edges and either diamond-hard steel or agate bearings, must be so constructed as to pass the Government Inspectors' test in compliance with the following scale :—

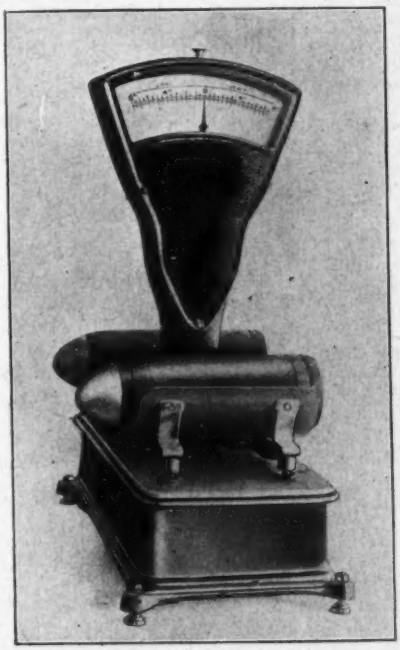
Capacity of machine.	Sensitiveness when fully loaded.	Greatest error allowed either in excess or deficiency when fully loaded.
1 oz.	½ gr.	½ gr.
8 ,,	1 ,,	1 ,,
1 lb.	1 ,,	1 ,,
2 ,,	1½ ,,	2 ,,
4 ,,	3 ,,	4 ,,
7 ,,	4 ,,	6 ,,
10 ,,	6 ,,	9 ,,
14 ,,	8 ,,	12 ,,
28 ,,	15 ,,	22 ,,
56 ,,	25 ,,	40 ,,
112 ,,	1½ drs.	2½ drs.
224 ,,	2½ ,,	3½ ,,
Above 2 cwt.	Add ½ dram for each cwt. of capacity.	Add 1 dram for each cwt. of capacity.

Weights and Measures Regulations, 1907, August 27; Statutory Rules and Orders, 1907, No. 698.

Amongst the most interesting problems facing the executives of works newly adapted to shell-making are the difficulties that arise as a corollary of the combination of dimension limits with weighing tolerances, for many shell cases that pass all dimension tests are found to be outside the allowable error of weight. Despite the research that has been devoted to the subject, no satisfactory solution has yet been reached such as would act as a reliable guide toward improvement. It is presumably accepted as true that a shell case will comply with the high weight limit if the low depth limit, mean diameter limit in the chamber, high limit in the exterior diameter, and the mean overall length are accurate, and that variation at other points produces only errors that can be corrected easily in the final weight adjustment. Exactly why this ruling has been commonly accepted is not clear. All the evidence appears to point to the conclusion that the ruling is false. The varying density of shell metals is so erratic that no dimension test can control errors of weight within working limits.

In the case of a Gnome cylinder cut from the solid steel and gauged, certainly to one-thousandth of an inch, errors in weight amounting to no less than four ounces are common before the final (and conclusive) weight test has been applied. Against the fact that the Gnome engine (which is selected for example merely as representative of the highest grade work produced) is considerably more complicated than is a shell case—mainly on account of its radiating flanges—we must set the fact that the thickness of the walls is little more than 1-16 in. and the weight about 8 lb. only. If, therefore, a micrometer or gauge set to one-thousandth of an inch is powerless to detect a weight error of 4 in 128 in one of the most perfect pieces of mechanism modern engineering skill can produce, even when the thickness of the *steel* is, approximately, only 1-16 in., how can it be safely assumed that a shell case must be correct in weight even within reasonable limits, because it passes the prescribed dimension tests?

In the search for efficiency the field is restricted to the quick-acting, automatic indicating scales, sufficiently sensitive for the purpose, counter and steelyard types together with beams being discarded as too slow in their adjustment for the work. One of the best scales we have seen for weighing shells up to 112 lbs. is the Pooley auto shell weigher, built upon the Beranger principle to designs patented in



The Pooley Auto Shell Weigher.

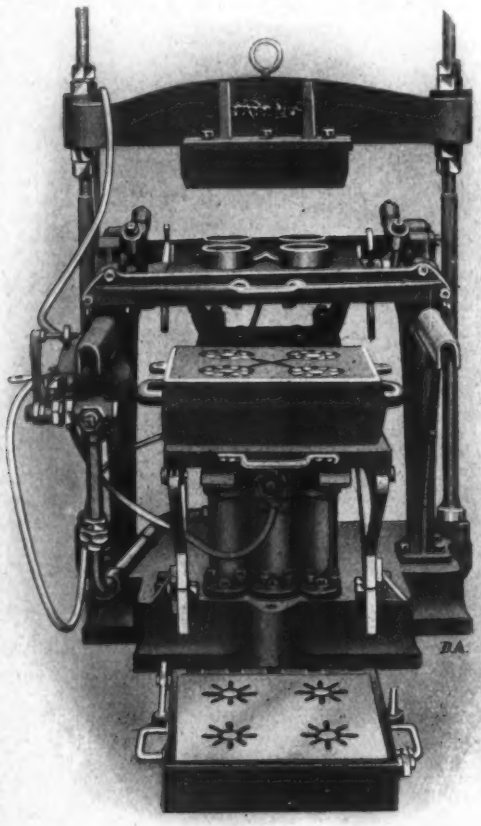
1911. The annexed illustration gives the general design of this scale, which, we understand, has been approved by the Board of Trade and also by the Admiralty. The chart indicates 8 oz. over and 8 oz. under weight by quarter-ounce gradations, and the 30-lb. capacity is particularly well suited to the 4.5 British H.E. shell, and also the 18-pounder. An outstanding feature of this scale is an ingenious device to prevent the effect of shock from disturbing or injuring the delicate indicator mechanism when loads are hurriedly thrown on or removed. This device consists of a break in the rod connecting the weighing levers with the indicator. The break is made by means of two engaged links, which part when the load is thrown on the one side, whilst hurried loading upon the reverse side merely results in jerking the indicating mechanism away from the working part of the scale that has been suddenly depressed, until the effect of the shock has been dissipated. The scale is made by Messrs. Pooley and Son, of John Bright Street, Birmingham.

D

The Brookhouse Moulding Machine.

The accompanying illustration shows the modern Brookhouse moulding machine for foundry work, made by Hodgson Hartley (1909), Ltd., Brookhouse Ironworks, Cleckheaton. Its construction and operation allow of its use for a comprehensive range of work, as it can produce cored moulds as quickly and as well as plain castings. The machine is driven by compressed air; it has sand-proof guards on all working parts, and all levers and taps are grouped together at the side of the machine.

As regards operation, the box, with auxiliary sand frame on top, is placed on the machine and filled with sand; the box is then pushed under the ramming head, the valve opened, admitting air to the cylinder below, which forces the piston upward, carrying the box to the ramming head, which enters



THE BROOKHOUSE MOULDING MACHINE.

the sand frame and rams the mould; the valve is then reversed, shutting off the air and opening the exhaust, allowing the machine and box to descend to its original position (in this operation the sand frame is required to prevent the sand flying sideways). The strength of the blow can be readily altered, and the same machine will answer for making moulds for either iron, steel, aluminium or brass. The ramming is done equally all over the mould, the face being hard all over.

When the mould has been rammed, the box is withdrawn from under the ramming head, the sand levelled down and the table turned over to draw the pattern. This is done by bringing up a small carriage underneath the box, automatically by the air pressure; the pneumatic vibrator is then started, loosening the sand from the pattern, and the box lowered slowly by the same means, thus drawing the mould completely from the pattern in a downward direction. The sand is thus assisted by gravity to leave the face of the pattern and is not in suspension, as when the box is lifted off the pattern. This system of drawing is claimed by the makers to be superior to any other, as no trouble is experienced by the sand dropping from the mould when drawing it or after it has been drawn. Stripping plates and stools are not required, but can be used if desired, and wooden patterns are frequently used. Patterns may be changed in a few minutes, and can be fitted to or cast on both sides of the pattern plate.

No skilled labour is required, as this machine can be worked by one handy man or labourer. The standard machine takes a box 16 in. by 16 in. by 6 in. deep, each half, internally; but smaller or deeper boxes can be used equally as well on the same machine. The Brookhouse machine is also supplied in sizes ranging from 16 in. by 14 in. to 30 in. by 24 in.; and also of a design to take from one to four different sizes of boxes and pattern plates.

THE INSTITUTE OF METALS.—The annual general meeting of the Institute of Metals will be held at Burlington House, Piccadilly, W., on March 29. The meeting will commence at 4 p.m., concluding the same evening. At the afternoon session the report of the Council on the work of the past year will be presented, the hon. treasurer will present his report, the results of the ballots for the Council for 1916 will be declared, and the presidential address will be delivered. A selection of Papers will be read and discussed at that and the evening session, the following being the order in which they are expected to be submitted:—(1) Third Report to the Corrosion Committee, by W. E. Gibbs, M.Sc., R. H. Smith, and G. D. Bengough, D.Sc., M.A. (2) "The Electrolytic Method of preventing Corrosion," by Elliott Cumberland. (3) "Note on some Tin-Aluminium-Copper Alloys," by Professor A. A. Read, D.Met., and R. H. Greaves, M.Sc. (4) "Notes on the Analysis of Aluminium and its Alloys," by W. H. Withey, B.A. (5) "The Annealing of Nickel Silver," by F. C. Thompson, M.Met. B.Sc. (6) "Electric Furnaces as applied to Non-ferrous Metallurgy," by Professor A. Stansfield, D.Sc., A.R.S.M. (7) "Transformation in Alloys of Gold and Copper," by Dr. N. S. Kurnakow, S. Zemczuzny, and M. Zasedateley. The sixth annual May Lecture will be given on Thursday, May 4, by Professor W. H. Bragg, D.Sc., F.R.S. (Nobel Prizeman), on "X-Rays and Crystal Structure with special reference to certain Metals."

NEW ACCOMMODATION FOR MINISTER OF MUNITIONS.—Mr. Lloyd George has, with his personal staff, removed from 6, Whitehall Gardens, S.W., to the offices of the Ministry of Munitions in Whitehall Place, which include the premises known as Armament Buildings and those formerly occupied by the Hotel Metropole.

Correspondence.

Chill Casting of Non-Ferrous Alloys.

To the Editor of THE FOUNDRY TRADE JOURNAL.

SIR,—On page 71 of your issue of February last is reported a lecture on the above subject, by Mr. F. Johnson, M.Sc., and, perhaps, I may be allowed to make a few remarks since the lecturer makes some reference to myself. Now, for practical working, there are greater limitations than the lecturer pointed out, because, outside some of the lower-temperature white-metals and alloys, permanent-mould castings (in brass and bronze, and, very incidentally, copper) must be confined to certain forms or shapes; for, unlike iron, the alloys do not freeze suddenly, and to attempt to make all castings in iron moulds is to court certain failure. Such things as wheels, wheel-blanks, trolley-wheels, and the like can be very successfully cast under suitable conditions, and flat castings come out well, but to produce in this manner such castings as a ported steam cylinder, or a water pump even, would not be a practical proposition, and, so far as I am aware, no one has yet claimed such to be the case. In no case is any kind of permanent-mould work either valuable or profitable, unless large numbers of castings of similar shape and size are needed, and beyond this the work of making the castings must be so arranged as to be continuous.

In regard to moulds, cast iron of suitable thickness would be the best, and probably any soft, grey iron, in which the combined carbon was low, would give good results; but certainly a high combined carbon content would be bad after a few hundred castings were made. As to the danger of breaking the moulds, this is too small to be considered, unless wilful damage is done, and people handling hot moulds do not usually burn themselves and so cause accidents. Malleable cast-iron is useless for permanent moulds, especially if partly machined, and wrought iron would be as bad, for very palpable, practical reasons. Of course, not every moulder knows how to get a smooth casting, but then not every junior clerk can keep a set of books. Even the moulder who can produce fine castings is sometimes unable to do so by reason of the absence of the necessary facilities, and this reference to moulders' abilities could have been left out, especially as in making permanent moulds the best available man for the job would be selected by 99 per cent. of foundry managers and foremen.

In regard to dressings for the moulds, a simple dressing with plumbago and water is sufficient at first, this being well polished from time to time, and, provided the moulds are kept dry, after some period of use even this is not often necessary, because the castings neither stick to nor alloy with the iron, contraction drawing the metal surfaces apart. Of course, all castings are thrown out hot.

The moulds must be vented for the removal of the enclosed air to be accomplished quickly, but there should be no gases formed in (or by) the molten metal, it being quite possible to have this fluid and clean if melted properly and the crucibles are not kept stewing in the furnace. Many people in charge of melting furnaces do not appear to realise the difference between melting metals and reducing them from their ores, and take as long to melt a pot of metal as is required to reduce the ores to the metallic form, and as a result they get a stew of metal and oxides thoroughly mixed. If melted in a proper manner the metal is got out clean, and if the moulds are poured as soon as the metal is ready clean castings are got; but if not, well, plenty of wasters are the result. There should be no necessity to use fluxes to clean the metal, but if anything is used the best thing now obtainable is dry zinc chloride, so far as aluminium and copper alloys are concerned. Zinc chloride is not the *best* flux or deoxidant, but it is the best now obtainable, other and better things not being prepared, or even likely to be prepared, owing to the silly prejudice that exists against using such things; and as they have never been patented they will not be again found without a lot of experiment. In any case it is possible to secure perfectly clean brass and bronze at a cost for flux not exceeding a halfpenny per 100 lb. of molten metal in ordinary times.

As to the future of permanent-mould casting, it appears to me that there is a good one, as there will probably be more standardisation of goods in the near future to secure economy of production; and with many things permanent moulds will effect a saving of from 50 per cent. to 75 per cent. on labour charges, even although the first cost of the moulds is necessarily large. Of course, it will also, in many cases, be necessary to use some good deoxidant flux made according to the metal or alloy being cast, but this is a matter of practice, which has to be individually decided.

In every case the whole matter has to be approached with an open mind, and quite apart from all preconceived ideas derived from practice in sand-moulding, while probably the practical metal-caster and the scientifically-trained metallurgist will both be called on to supply deficiencies in each other's work. Anyhow, the results will prove the correctness of working, but it is necessary to disabuse the mind of all ideas as to the impossibility of casting in permanent moulds all or any metals or alloys, before decent results can be secured in any form.

Yours, etc.,
WALTER J. MAY.

Alloys for Aluminium Cooking Utensils.

To the Editor of THE FOUNDRY TRADE JOURNAL.

SIR,—In your issue of January, under "Non-Ferrous Notes," you give "Alloys for Aluminium Cooking Utensils," and we wish to draw your attention to the fact that the alloys suggested are unsuitable for the purpose. The only satisfactory aluminium cooking utensil is the one cast in the purest possible aluminium, and for this purpose we ourselves use no metal other than virgin ingot aluminium guaranteed over 99 per cent. Much harm and prejudice has been created through the use of alloys such as you suggest. The presence of even a slight addition of copper will cause the utensil to pit when in use, and when spelter is added this is even more pronounced, with bad discoloration.

We regret to trouble you in this matter, but feel constrained to write in the interests of the aluminium cooking-utensil business.

THE ALUMINIUM CASTINGS COMPANY, LIMITED,
Ingleston Foundry,
Greenock, N.B.

HYDROGEN IN ELECTROLYTIC IRON.—In their experiments on electro-deposited iron (practically free from carbon) Guillet and Portevin found that the metal as taken from the electrolytic bath was supersaturated with hydrogen and was extremely brittle. It showed a characteristic microstructure which, however, became normal after annealing in magnesia at 900 deg. for two hours. It was found that the iron as electro-deposited contained 0.014 per cent. of hydrogen, while the annealed metal contained 0.008 per cent.

Non-Ferrous Notes.

Statuary Bronze.—The following has been recommended as a good mixture for casting statuary:—Copper, 90 per cent.; tin, 7 per cent.; zinc, 2 per cent.; lead, 1 per cent.

Affinity of Metals for Oxygen.—The tendency of most foundry metals to combine rapidly with the oxygen of the atmosphere is well known, but the relative affinities of the different metals for oxygen is not so well appreciated. The following metals are given in the order of their affinity for oxygen:—Magnesium, calcium, aluminium, strontium, barium, silicon, potassium, sodium, manganese, zinc, iron, phosphorus, and lead.

Casting Patterns.—Patterns cast in metal, naturally, are required to have a good surface; but to secure this care must be taken not to have the metal too hot. The moulds can be of green sand lightly rammed, but should be as dry as possible for proper working. If such a mould is poured with metal too hot, one or other face (probably the bottom) will be bad. The metals usually employed for patterns can be cast at a relatively low temperature, and in fact should be so cast in order to get the best results.

Melting Point of Pure Manganese.—Pure manganese, 98 per cent., carbon-free, is used by many foundrymen in the manufacture of cupro-nickel, German silver and other nickel alloys. The melting point of 97 to 98 per cent. pure carbon-free metallic manganese is considerably lower than that of pure iron, the two differing by from 225 to 250 deg. C. A recent booklet of the United States Bureau of Standards gives the following determinations of melting points:—97 to 98 per cent. pure manganese metal carbon-free, 1,255 deg. C.; pure iron, 1,478 to 1,533 deg. C.

Analysis of Chinese Antimony.—The results of analysis of Chinese antimony made by W. B. Schoeller were as follows:—Antimony, 98.2 per cent.; arsenic, 0.148 per cent.; iron, 0.146 per cent.; copper, 0.025 per cent.; lead, 0.006 per cent.; zinc, 0.025 per cent.; insoluble, 0.076 per cent.; sulphur, 0.37 per cent. Antimony ores occur in the south of Hu-Peh and part of Sze-chuen province, and in the provinces of Kwei-chow, Kwang-si, and Yun-nan. Roughly speaking, this vast antimony belt comprises the entire western half of China south of Yang-taze-kiang.

Graphite Stirrers.—In some melting practice the use of graphite stirrers and skimmers is a great advantage; in fact, almost a necessity. They are used to some extent in the brass rolling-mill foundries, the object being to prevent the entrance of iron into the molten metal. Iron skimmers are apt to introduce iron into the various metals, and for the best quality of brasses and bronzes the presence of iron is injurious. This is particularly true of such metals as German silver, cartridge and spinning brass, etc. Graphite stirrers should always be used in making phosphor-bronze, as the phosphorus in the metal attacks iron rapidly.

Plugging Blowholes in Castings to be Plated.—Castings which have to be electro-plated are often marred by blowholes which do not affect other than by their appearance. A method of plugging these holes used by some concerns is as follows:—Drill into the hole with a bit less in diameter than the blowhole, and drive into it a piece of copper wire, leaving the end long enough, and then rivet it down so as to fit the cavity. It is unnecessary to drill a hole that will cut out the entire blowhole. This method of plugging blowholes does not take long, and the surplus copper can easily be filed off even with the casting. After this has been done it can be nickel-plated, and the blowhole be quite disguised.

Manganese-bronze Test Bars.—It is not uncommon to find considerable irregularities in manganese bronze test bars, particularly if the rates of cooling are not alike. Speaking generally, if the centre of a test-bar cast in sand be examined after it is broken, it will usually be found to be of different structure from the outside portion. If it be manganese-bronze, the centre probably will be light yellow and crystalline. The lower the tensile strength the greater the quantity of crystalline material in the centre. It is this crystalline centre that causes the difference in the tensile strength. A bar which is cooled very rapidly by casting in a chill mould is usually homogeneous throughout, and shows no crystalline structure.

Lustrous White Alloy.—An alloy of high lustre, capable of taking a brilliant polish and closely resembling silver in appearance, which was patented by E. Smith, London, was claimed to have the property of withstanding atmospheric conditions to a great extent. The mixture is as follows:—Copper, 40 lbs.; nickel, 8½ lbs.; zinc, 5 lbs.; tin, 2½ lbs.; lead, 1 lb. The nickel is first melted with a flux of silica, and half of the copper added gradually and mixed, after which the remainder of the copper is added. The zinc is then quickly plunged beneath the surface of the molten metal, which is stirred rapidly till the whole is melted. The lead and tin are added last. The metal is stirred and brought up to 1,700 deg. F., then poured into ingot moulds.

Bismuth and Cadmium in Solder.—The use of bismuth and cadmium to cheapen the ordinary soft solders is claimed to be practicable, although these metals are expensive. By adding bismuth and cadmium to an alloy of lead and tin, the melting point is lowered. Therefore, it is possible to use more lead in the solder and still have it flow as readily and freely as ordinary soft solder. When both bismuth and cadmium are used, the melting point is lower than when only one of the metals is employed. A small quantity only of the addition is required. The following mixture has been found to give good results:—Lead, 75 per cent.; tin, 23 per cent.; bismuth, 1 per cent.; cadmium, 1 per cent. The metals can be melted together and fluxed with a small piece of rosin. This will remove what dross has formed during the melting, and produce clean and easy-flowing metal. This solder is intended to replace that of equal parts of tin and lead.

Use of Charcoal in Brass Melting.—Practically every brass rolling mill, whose product is of a higher grade than that of the brass foundry, uses charcoal in melting. Its function is to prevent the oxidation of the metal during the melting. Small coal or coke is frequently used in place of charcoal, but is inferior on account of the presence of sulphur. Repeated trials have demonstrated that the quality of the melted metal is invariably the best when charcoal is used. The advantage of charcoal in melting lies in its absolute freedom from sulphur and hydrocarbons, and at the same time it burns readily, thus supplying a reducing atmosphere. To obtain the best results it should be crushed to small size and be slightly damp. A small quantity should be placed in the bottom of the crucible, before the metal is put in, and more as soon as it begins to melt. At all times the molten metal should be well covered with it. Sawdust can be used, if desired, but it is almost too fine to remain on the metal if there is a strong draught; but it is better than nothing at all.

Nickel Alloys for Electrical Work.—To obtain carbon-free nickel alloys is a somewhat difficult matter in practice. A method of so doing was accordingly developed and patented a few years ago in America by J. T. H. Dempster, of the General Electric Company. The nickel alloy used was:—Nickel, 62; iron, 20; chromium, 13; manganese, 5. This alloy was required for resistance wire, and in order to draw it into wire or roll into sheet, no carbon should be present. If an ordinary graphite crucible is used, the metals take up so much carbon that they cannot be drawn. Commercial nickel contains a small amount of carbon, and it was found necessary to purify it in the crucible while melting. The method was as follows:—The crucible used was of the ordinary graphite type lined with a fire-clay mixture, so that the metal did not come in contact with the graphite. In the bottom of the crucible red oxide of iron, or hematite ore, was placed, using for 100 lbs. of the alloy melted, 8 lbs. of this oxide of iron. The nickel was then charged into the crucible on top of the oxide of iron, and a

small quantity of silica and cryolite added for a flux. When the nickel was melted, the heat was increased to promote a vigorous action between the oxide of iron and the carbon in the nickel, the gas bubbles escaping from the molten metal and burning with a blue flame. After the nickel had quieted down and the gas had all escaped, the iron and chromium were introduced, and when the mass was thoroughly melted, the manganese was added. The mixture required to be poured as soon as the manganese had melted, in order to prevent the attacking of the clay lining. The resulting alloy was so ductile that it would draw into wire.

Rose Metal.—Rose's alloy, or Rose metal as it is sometimes termed, is composed of about 42 per cent. lead, 42 per cent. bismuth, and 16 per cent. tin, the working proportions being: Lead 8 lbs., tin 3 lbs., and bismuth 8 lbs. It melts at about 90 deg. C., and is about as hard as hard lead. By the addition of a small proportion of cadmium, the freezing point can be lowered to 70 deg. C., while with a small amount of mercury an alloy can be produced which melts at about 37 deg. C., or about blood heat. Such an alloy is sometimes used by anatomists for taking casts of the human body.

Yellow Brass for Machining.—As a matter of economy it is necessary for yellow brass castings which are to be machined to be sufficiently soft to admit of free cutting at the desired speed. In the brass-finishing trade the term "hard" is applied to metals which do not cut freely, and really often designates a tough metal. Yellow brass which does not contain enough lead to render it free cutting is called hard, yet the metal is soft. In other cases, however, the metal may actually be hard in both senses, due to the presence of iron. One writer records trouble with hardness in gas fixtures of the following analysis: Copper, 65.42 per cent.; zinc, 29.25 per cent.; lead, 4.58 per cent.; iron, 0.56 per cent. This mixture, as far as the copper and zinc are concerned, is correct; the lead is present in a sufficient quantity to render the mixture very free turning. The cause of the hardening is the iron, and it is present in an amount sufficient to produce a noticeable hardening of the brass. The brass was made entirely from scrap, and in encountering the introduction of iron by this means the user was not by any means in an uncommon difficulty.

White Metal for Typewriter Parts.—A strong white metal is frequently used for casting typewriter parts which are constantly handled, like the spacing levers and shift-keys, and has the advantage that it does not corrode or rust like steel. The alloy is white, but tarnishes slightly when exposed to the air, although it does not corrode. For this reason it is frequently nickel-plated. When the nickel wears through, however, it can scarcely be noticed. The white-metal mixture is as follows:—Copper, 57 per cent.; zinc, 20 per cent.; nickel, 20 per cent.; aluminium, 3 per cent. First the nickel is placed in the bottom of the crucible with an equal weight of copper, and covered with a thin layer of borax, and over this a layer of charcoal. The heat is raised until the nickel melts, and the metal is then stirred. The object of putting part of the copper in with the nickel is to cause the nickel to melt more readily. When the nickel has melted it is well stirred, and the rest of the copper added. When all the copper has melted, it is stirred and the aluminium added. When this has been stirred, the temperature of the crucible rises, and the metal becomes almost white hot by the reaction between the copper, nickel, and the aluminium. The crucible and its contents are allowed to cool down before adding the zinc, to avoid excessive loss by volatilisation. If scrap of the same mixture is had, it can be used to cool the mixture, but if not, then it will be necessary to allow the crucible to remain for a while until its temperature has become lower. The zinc is added, and the whole well stirred, poured into ingots, and then remelted for making the sand castings. Better castings are always obtained when the metal has been melted twice. The metal is as white as nickel, and casts well in sand. The pouring temperature, however, must be low, and on account of the aluminium in it the metal runs well. The right heat for ordinary work is when no spelter smoke is given off from the undisturbed surface. This alloy is very stiff, and will not bend without breaking. When cast, after it has been melted twice, the castings are usually free from pin-holes and take a high polish. The sand for the mould should be as dry as possible, and the patterns should contain no sharp corners.

White Metal Bearings for Locomotives.—The bearings and other working parts of a locomotive are required to be of ample proportions for the weight they have to carry, or other work they have to do, if good results are looked for in service, says a writer in "The Locomotive." Within certain limits the softer the soft bearing, the better the result obtained, and the material generally employed is that which is known as white metal, or Babbitt. Nearly every railway has its own formula for the mixture, but a typical one may be taken as 73 parts by weight of tin, 10 parts of antimony, and 4½ parts of copper. These are melted up in the foundry and supplied in blocks to the white-metallers, who heat to a molten state for use, and add 12½ parts of zinc before use. In locomotive axle-boxes it will usually be found good practice to cast the bearing area with recesses in the face, into which the white metal is run, and then turned up with the axle-box so that the actual bearing face is partly gunmetal, but more largely white metal. In some cases it is possible to make one of the wearing faces entirely of white metal, in which a very thin layer is attached to the harder metal. However, it will be found best to provide for the harder metal to project all round the softer white metal, to prevent the edges breaking off. At least some form of "key" will be necessary, such as serrations in the hard metal or holes in which the white metal can penetrate and get a grip. Tender bearings, for instance, are often made with practically their whole bearing area of white metal, and they give excellent results if care be taken to make the white metal adhere firmly to the axle-box proper. The article to be white-metalled has first to be thoroughly cleaned from scale or rust at those parts which are required to be lined up, either by turning, filing, or chipping, or by immersion in an acid bath. The latter method is preferable, but not always possible. When the surfaces are thoroughly clean, the article is heated to a temperature sufficient to make tin melt freely, say 450 deg. F. Then a stick of tin is dipped into salammoniac and rubbed on to the parts to be metalled, and thus a very thin coating is deposited. This operation has to be carried on until the whole surface is covered with a layer of tin. This is necessary in order to ensure that the white metal is in firm metallic contact with the article to which it is required to be attached. The white metal is now poured on to the tinned parts, and guided and pressed into position by means of a hard smooth stick of wood. Whilst in a plastic state the white metal is easily controlled, and a layer of almost any thickness can be spread on to the skin of tin, to which it will firmly adhere. If a large number of articles, such as carriage or wagon brasses, are to be white-metalled up, it will be found better to dip them into the white metal itself to "tin" them; then place the brass, while still hot, into a suitable mould, which is constructed to open to receive the brass, and is then keyed up so as to leave only room for the required thickness of white metal, which is poured from a ladle into a proper-shaped funnel or runner. The mould is, of course, heated to about the same temperature as the brass, so that there may be no "blowing-out" of the metal being poured in. Before dipping the brasses into the white metal all the parts that are not required to be tinned are painted over with whiting, which resists the action of the metal. When cooled off a little, the mould is opened and the brass taken out and laid aside to get cold, and the mould used again as often as necessary. When cold, and before passing the brass to the fitters, each is tested by "ringing" it—that is, it is held loosely and struck smartly with a hand hammer in various parts, and by the sound it can be easily known whether the metals are in firm contact, as, if not, the sound will be cracked.

Trade Talk.

Mr. W. H. Patchell has removed his offices from Caxton House, to 64, Victoria Street, S.W.

The Spanish Government has now taken off the duty of 100 pesetas per 100 kilos net imposed on the export of zinc.

The Partington Steel & Iron Company, Limited, have purchased land in the vicinity of their works at Irlam, Manchester, for the purpose of extension.

The Government has decided to grant facilities to shipbuilders to enable them to finish vessels nearly completed of the tonnage of approximately 500,000.

Matthews & Yates, Limited, of the Cyclone Works, Swinton, are about to still further enlarge their premises in order to meet the exigencies of an increasing business.

The Coatbridge Dean of Guild Court have sanctioned the erection of a new building by William Beardmore & Company, Limited, at the Speedwell Ironworks.

Messrs. H. Mackay & Company, engineers and merchants, have removed from 4, Southampton Row, W.C., to Norfolk House, Laurence Pountney Hill, London, E.C.

The shareholders of Nedenes Molybdenite, Limited, will meet at 12, Coleman Street, London, E.C., on March 24, for the purpose of considering the liquidator's report.

Mr. H. Richardson, ironfounder, carrying on business at the Barn Meadow Ironworks., Ashton Street, Dukinfield, is paying a first and final dividend of 14s. 7½d. in the £.

The shareholders of the Johnson Steel Syndicate, Limited, have decided that the company be wound up voluntarily, and have appointed Mr. G. L. Haslehurst, of Lincoln, liquidator.

A receiving order has been made in connection with the affairs of Mr. J. P. Williams, trading as Williams Brothers, at the Southwark Iron Works, 34a, Essex Street, Mare Street, Hackney, N.E.

Mr. Alexander Morrison, of 12, Waterloo Street, Glasgow, has been appointed by Messrs. John Wright & Company, Eureka Works, Thimble Mill Lane, Birmingham, as their agent in Scotland for gas-heated furnaces.

Before the members of the Sheffield Society of Engineers and Metallurgists, an instructive lecture was delivered by Mr. L. Aitchison on "The Relation of Constitution to the Corrosion of Steel." Dr. Arnold presided.

A meeting of the members of the Variable Blast Pipe Company, Limited, in voluntary liquidation, will be held at 68, Victoria Street, Westminster, London, S.W., on Friday, March 24, to receive the report of the liquidator.

The Holm Forge Company (Bellshill), Limited, and the Bathgate Forge, Limited, have been amalgamated. Mr. Andrew Hughes, managing director of the latter company, will manage the combined businesses in future.

The shareholders of J. & A. Taylor, engineers, Townhead Works, Smith Street, Ayr, have decided that the company be wound up. Mr. J. Leslie Doran, chartered accountant, Glasgow, has been appointed liquidator.

Messrs. T. Underwood, A. Underwood and W. Underwood, tool makers, etc., 13 and 15, Manchester Road, and 4, Wilton Street, Bradford, trading as Thomas Underwood & Company, have dissolved partnership.

The business of engineers, crane, and chain makers, carried on by D. Watson & Company at Harmony Row, Govan, Glasgow, has been sold to Mr. McLean, 161, North Street, Glasgow, who will continue the business under the same name.

The partnership heretofore subsisting between Messrs. A. Ogden and R. R. Lawson, brass founders and brass finishers, Workington, and Barrow-in-Furness, trading under the style of Ogden & Lawson, has been dissolved. Mr. Lawson continues.

Merry & Cuninghame, Limited, purchased the Ardeer Ironworks, etc., at Stevenston, Ayrshire, from the Glengarnock Iron & Steel Company, Limited, for the sum of £250,000. It will be remembered that the change of ownership took place on December 1, 1914.

The Daimler Company, Limited, announce that Daimler lorries can now be supplied to firms engaged on Government contracts, but enquirers should state fully the work on which the vehicles will be used, as every delivery must be sanctioned by the War Office before delivery can be given.

Messrs. Macdonald & Mackinlay, engineers and contractors, 128, Hope Street, Glasgow (of which Mr. H. Macdonald and Mr. I. B. Mackinlay were the sole partners), have suspended payment, and have granted a trust deed on behalf of their creditors in favour of Mr. W. Houston, 140, West George Street, Glasgow.

The Minister of Munitions has made an order under section 4 of the Munitions of War Act, 1915, declaring 116 additional works as controlled establishments under the Act as from February 14, 1916. A total of 2,834 establishments have now been declared as controlled under the Act, from the date of the first order, July 12, 1915, to February 10, 1916, inclusive.

Mr. G. J. Stock has disposed of two more Snyder furnaces to companies in Great Britain. The National Steel Foundry Company, Limited, of the Kirkland Works, Leven, Fife, have contracted for one furnace having a capacity of 6 tons per 24 hr., while Thwaites Brothers, Limited, of the Vulcan Ironworks, Bradford, will instal one more furnace, having a capacity of 12 tons per 24 hr., making two of this capacity. The above furnaces make a total of five of this type now operating or contracted for in this country.

The Board of Trade have appointed Sir Edwin Cornwall, M.P., to be a member of the Advisory Committee in connection with the Trading with the Enemy Amendment Act, in place of Sir George Croydon Marks, M.P., who finds himself unable to serve on the Committee owing to the continuance of his work for the Ministry of Munitions. Sir George Marks is at present acting on behalf of the Minister of Munitions as Special Commissioner in the Tyne district to deal with the inauguration of schemes for the dilution of labour.

The Minister of Munitions has officially announced that there is now no reason why married men of military age, who have been attested and placed in late groups, should not be trained for munitions work. Such men will be accepted for training on the understanding that they will have to join their groups when they are called up. If they subsequently undertake work which entitles them to wear war service badges, they will not be called up for service unless the Ministry of Munitions decides that they are more urgently needed in the Army than for munitions work.

Meetings of the creditors and shareholders of Hartley, Causton & Richmond, Limited, ironfounders and constructional engineers, of London, Stoke-on-Trent, and Renfrew, were held on February 22, at the London Bankruptcy Court, before Mr. H. F. Burgess (Official Receiver). Accounts have been lodged showing total liabilities £80,707 (unsecured £36,535) and assets valued at £40,727, which are absorbed in the claims of the debenture holders. The account with the contributors disclosed a deficiency of £91,141. The liquidation was left in the hands of the Official Receiver.

The quarterly statistics of the Middlesbrough Chamber of Commerce show that at the end of 1915 of 77 blast-furnaces erected within the port of Middlesbrough 43 were in operation, against 49 blowing 12 months ago. The output of pig-iron within the port of Middlesbrough during 1915 is estimated at 2,154,000 tons, of which 1,095,000 were Cleveland pig, and 1,059,000 hematite and special irons. In 1870 the make totalled 964,266 tons, and in 1914 2,391,000. The quantity of foreign ore imported to Middlesbrough last year amounted to 1,816,912 tons, compared with 1,819,813 for the previous 12 months.

In the House of Commons recently, during a reply to Mr. Llewelyn Williams, who asked a question regarding the number of moulders unemployed at present, Dr. Addison referred to the answer given on December 13 last, in which he pointed out that the work of moulders was specialised to a very high degree. There was at the present time an unsatisfied demand for upwards of 400 moulders of different grades, although the vacancies had been circulated to every Labour Exchange in the country. Any of the unemployed men referred to in the question who were, in fact, capable of filling these vacancies and willing to do so, could at once be placed in employment in them.

The Council of the Institute of Industry (of Great Britain and Ireland), Limited, has appointed a special committee of its Court of Directors to meet representatives of important trade interests with a view to considering suggestions having for their purpose the strengthening of the Court of Directors, and the co-operation or amalgamation of other similar movements. The committee appointed is as follows:—Mr. F. J. Nettlefold (chairman), Sir Clifford J. Cory, Bart., M.P. (Cory Brothers & Company, Limited), Sir James Heath, Bart. (R. Heath & Sons, Limited), Mr. Godfrey C. Isaacs (managing director of the Marconi Wireless Telegraph Company, Limited), Mr. Frank Warner.

Negotiations will shortly be completed, we understand, between the Tees Bridge Iron Company, Limited, Stockton-on-Tees, and Pease & Partners, Limited, for the purchase of the works and business of the former company. The company have a capital of £44,175 in £5 shares, and mortgages and charges to the extent of £15,000. The plant consists of three blast furnaces. Pease & Partners, Limited, who have a capital of £1,300,000, and debentures aggregating £525,000, have a large interest in the Skinningrove Iron Company, Limited, and in 1911 the undertaking of the Normanby Iron Works Company was acquired. The company are large coal and ironstone mineowners, and their plant consists of four blast furnaces at Normanby, and three at the Tees Ironworks.

A sub-committee has been appointed by the British Electrical and Allied Manufacturers' Association to concentrate public attention on the increased importance of the whole engineering industry from the point of view of national safety and revenue earning power when normal conditions are restored. The country will possess, on the return of peace conditions, an engineering industry of enormously greater and more efficient productive capacity, and it is believed that the intelligent utilisation of these sources of wealth may prove the most important of all factors in solving the problem of rapid restoration of prosperity—by affording a continuance of remunerative employment—for our large army of skilled and unskilled munition workers, and for an important proportion of the men released from military service.

Mr. G. Mure Ritchie, speaking at a meeting of the Furness Railway Company, referred to the congestion on the railway, especially at Barrow. That congestion had been a very serious thing to the iron companies on the line, and he hoped the general manager could give some reasonable assurance that it was likely to be, as nearly as possible, completely removed, because it was a very serious thing when blast furnaces were compelled to be operated literally from hour to hour through being short of raw materials. That had been the case recently, with the result that the operation was much more difficult and more costly. He was aware that the railway companies had had the most phenomenal difficulties in coping with traffic, owing to sudden demands from all quarters, and especially the Government requirements. At the same time the Iron Works on the West Coast were practically doing nothing but Government work, and everything that could be done to facilitate normal operations was helping the Government.

An Order in Council was published in a supplement to the "London Gazette" recently making sundry amendments and additions to previous proclamations respecting prohibited exports. The clauses of the new Order are as follows:—(1) That the heading "Hematite pig-iron" in the list of goods the exportation of which is prohibited to all destinations should be deleted, and there be substituted therefor the heading:—Pig-iron of the following descriptions:—(*a*) Pig-iron containing less than 0.1 per cent. of phosphorus, including hematite pig-iron; (*b*) all other pig-iron containing more than 0.1 per cent. of phosphorus, but less than 1.5 per cent. of silicon together with less than 0.09 per cent. of sulphur. (2) That the exportation of the following goods should be prohibited to all destinations:—Cerium, oxide and salts of; cerium and its alloys (except ferro-cerium). (3) That the exportation of ferro-cerium should be prohibited to all destinations abroad other than British possessions and protectorates.

Contracts have now been placed for a considerable portion of the plant and machinery required for the new steel works of Messrs. Dorman, Long & Company, at Redcar. This firm recently purchased the Warrenby Furnaces from Walker, Maynard & Company, Limited. At the present time only one of the furnaces is in full blast, but it is understood that steps are being taken to put others in operation. The works are situated at a short distance from the mouth of the River Tees, and adjoin the land on the Wilton Estate, which, according to the speech of Lord Knaresborough at the annual meeting of the North-Eastern Railway Company at York last week, was acquired by the company, at a cost of £99,000, for the purpose of establishing deep-water berths for dealing with the growing trade of the Tees port. The developments are bound to have a great effect on the future of Redcar. The low rating of this part of Cleveland is particularly a factor. In normal times the total calls only amount to 5s. in the £.

The success appertaining to the introduction of female labour into industries and vocations calling for much skill has been truly remarkable during the last eighteen months, and every day seems to bring with it a fresh surprise in this direction. The latest work to attract the fair sex is oxy-acetylene welding, an industry which is itself in its early stages. Ever since the Active Service Branch of the National Union of Women's Suffrage Societies was formed it has kept to the fore a programme of practical effort, and in September last was opened the first school for the teaching of this craft to women. Amongst the members of the Union is Miss E. C. Woodward, a lady who has attained considerable distinction in artistic metal-work. The school is situated in Johnson Street, Notting Hill, London, W., and the whole course is taught for three guineas, plus half-a-crown a week for materials used or spoiled. Six weeks' training is usually enough to equip a girl to take her place in the actual factory. Even before the war there was no superfluity of men who were doing this kind of work, for the temptation with them, when they had attained proficiency in it, was to go on to the still better-paid labour of metal-cutting by oxygen. Of the first students who passed out of the school five started at a factory near London, working for the Government, and on the morning of their first day's labour they went straight to their benches without exciting any comment.

Six Birmingham technical societies, namely, the Society of Chemical Industry (Birmingham section), the Institute of Metals (Birmingham section), the Staffordshire Iron and Steel Institute, the Birmingham Association of Mechanical Engineers, and the Birmingham Metallurgical Society, met on Friday, February 11, to hear a lecture by Dr. Walter Rosenhain on "The Making of a Big Gun." Mr. Rees, of the Society of Chemical Industry, presided. Dr. Rosenhain traced the various developments of the gun from the smelting of the ore until its final shooting trials, and a realistic character was given to the description by the ample use of lantern slides and cinematograph films, showing the operations of running the metal from the blast furnace, casting from four Siemens' furnaces the 80-ton ingot, squeezing under the 10,000-ton hydraulic press, the tempering of the tube by plunging in the oil bath, wire-winding, the turning and

rifling of the gun, and the firing. A remarkable cinema photo was the interior of a Siemens' furnace, showing the boiling metal. The lecturer showed by some exhibitions of old guns how rapid had been the evolution of this powerful arm. The comparatively feeble explosion of the old gun the lecturer attributed to the shortness of the tube, which gave insufficient time for the development of explosive force. The great generation of heat accounted for the early breakdown of a small proportion of the guns, through internal cracking. The speaker explained the necessity for improving the metal to the highest extent, especially by the removal of the weak element graphite. A series of excellent micrographs showed how the uniformly powerful metal was secured, chiefly by judicious heat treatment.

Legal.

Pig-iron Contracts Dissolved.

In the King's Bench Division on March 1, before Mr. Justice Rowlatt, the Distington Hematite Iron Company, Limited, of Distington, near Whitehaven, brought an action against Messrs. Possehl & Company, of Lubeck, Germany, claiming that a contract made between the parties on July 20, 1911, should be declared dissolved because of the war. Plaintiffs also asked for a declaration that all obligations thereunder to supply pig-iron to the defendants should also be dissolved, without prejudice to obligations previous to the outbreak of war.

Counsel for the plaintiffs said they agreed to give the defendants the sole sale of their pig-iron in Europe, and the defendants were to take amounts of not less than 3,000 tons per annum from 1912. No liability attached to the non-taking of the full amount of 3,000 tons, but in the event of failure in this respect the plaintiffs had the right to take away the sole sale. In the event of strikes the plaintiffs were not obliged to deliver, and there was another clause in the agreement that the defendants should not be obliged to take any deliveries in case of mobilisation or war in which Germany might be interested, but only for the duration of such trouble. This contract was signed in 1911. Ten contracts were affected under the agreement. Two had been partly fulfilled, and eight had not been dealt with. Counsel submitted that the clause making the defendants the sole agents in Europe was equivalent to a restrictive covenant preventing the plaintiffs from supplying any one else in Europe; it would prevent plaintiffs supplying our Allies with iron. Defendants were claiming to be entitled to compel the plaintiffs to keep thousands of tons of iron until after war was over. Counsel submitted that, as the agreement was against the interest of the country and was impossible of fulfilment, it was void.

Counsel for the defendants said contracts in time of war were only void when they involved commercial intercourse with persons in an enemy country during war. That was not the case where a contract was capable of suspension. This contract was capable of suspension, and ought not to be declared void. Pending deliveries to defendants would be cancelled, but the general agreement was not.

His Lordship said the agreement required continuous effort on both sides, and the war had put an end to its performance indefinitely. It being a contract which could not from its terms be postponed, the result was that the contract was dissolved. He made the declaration asked for in plaintiffs' favour, with costs.

NICKEL REFINING IN CANADA.—The International Nickel Company has decided to erect a nickel refinery in Canada, in order to co-operate with the Canadian Government in its desire to have some of the nickel ore mined in the Sudbury district of Canada refined in the Dominion. The arrangement arrived at is said to be satisfactory to both the Canadian Government and the company.

Personal Paragraphs.

Estate valued at £17,359 was left by the late Mr. A. G. Neilson, iron broker, Glasgow.

The late Sir Edwin Hamer, of Henry Livesey & Company, engineers, of Greenbank, left £41,834.

The gross value of the estate of the late Mr. S. B. Clapham, of Aireville, Keighley, ironfounder, is £14,674.

The late Mr. C. B. Catt, a director of Henry Berry & Company, Limited, engineers, of Leeds, left estate valued at £18,070 gross.

Sir Lincoln Tangye, Bart., has been elected chairman of Richard Hill & Company (1899), Limited, of Middlesbrough, in place of the late Mr. F. W. Manson.

Mr. A. Pegler has been elected a director of the Weardale Lead Company, Limited, to fill the vacancy on the board caused by the death of the late Mr. John Cameron Swan, J.P.

The late Colonel T. E. Vickers, C.B., who was chairman and managing director of Vickers, Limited, and chairman of the Carlton Main Colliery Company, Limited, left unsettled estate valued at £117,347 gross and £106,899 net.

The council of the Royal Society of Arts have presented their Albert Medal to Prof. Joseph John Thomson "for his researches in physics and chemistry, and their application to the advancement of arts, manufactures, and commerce."

The announcement is officially made that Lord Pirie, the chairman of Harland & Wolff, Limited, of Belfast, has joined the board of directors of John Brown & Company, Limited, and that Lord Aberconway, the chairman of John Brown & Company, Limited, has joined the board of Harland & Wolff, Limited.

The Hon. Sir Charles A. Parsons has been elected a member of the Advisory Council of the Committee of the Privy Council for Scientific and Industrial Research, in place of Professor Bertram Hopkinson, who has resigned. Professor Jocelyn Field Thorpe has been appointed to fill the vacancy on the Advisory Council caused by the death of Professor Raphael Meldola.

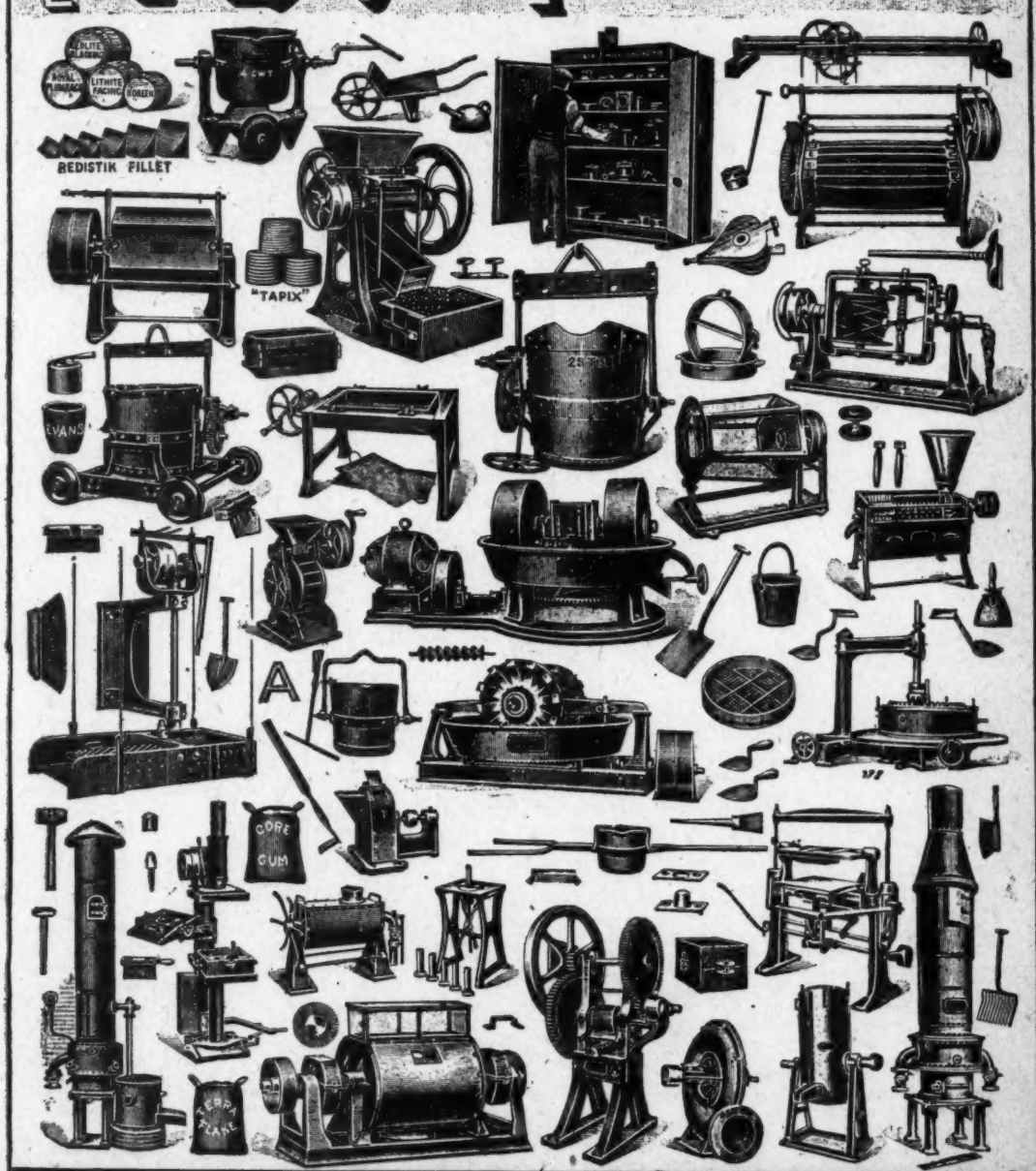
Mr. M. Workman has been elected president of the Dominion Steel Corporation, Sydney, Cape Breton, in place of Mr. J. H. Plummer, who has become chairman of the board. The company will shortly engage a steel expert to supervise the operations of the plants and to advise as to its general policy. Mr. H. McInnes, chief counsel of the company, has been elected a director.

Mr. F. J. Cook, a past-president and one of the original members of the British Foundrymen's Association, to whose proceedings he has contributed a number of papers and addresses, has resigned his position as foundry manager to the firm of Belliss & Morcom, Limited, Birmingham, and has become a director of the Giles Foundry and Rudge-Littley, Limited, Swan Village, West Bromwich. His connection with the firm of Belliss & Morcom extended over twenty-five years, including seventeen as foundry manager. Mr. Cook succeeds Mr. F. J. Giles, who has retired. The firm represents two old and well-known foundry businesses, that of Rudge-Littley & Company, Limited, West Bromwich and the Giles Foundry Company, formerly of Birmingham, the latter having been transferred to Swan Village on the amalgamation of the two firms about twelve months ago. The firm, whose premises occupy a site of five acres, is engaged in the casting of grey iron, brass, aluminium, phosphor bronze and malleable iron. The malleable iron side has a particularly up-to-date plant with a 5-ton Siemens furnace in addition to a foundry cupola. The works are driven throughout by electricity and the heavier foundry departments are equipped with continuous electric travellers. In the malleable-iron foundry castings from the lightest up to any reasonable size can be dealt with. The grey iron and brass foundries are devoted chiefly to machine tools and other engineering requirements.

COMPLETE

Foundry Equipment.

Telegrams: "LADLES MANCHESTER"
Telephone: "N° 2297 CENTRAL" MANCHESTER.



JAMES EVANS & Co. BRITANNIA WORKS,
BLACKFRIARS, MANCHESTER.

Deaths.

Mr. W. Young, formerly of J. & T. Young, Vulcan Foundry, Ayr, has died at the age of eighty-three years.

Captain J. Whytock, manager of the Parkhouse Iron Foundry, Falkirk, died at the Western Infirmary, Glasgow, on February 21, aged 61 years.

Mr. William Rowan, late senior partner of the firm of William Rowan & Sons, engineers, Park Lane, Bridgeton, Glasgow, died on February 20.

Viscount Ridley, whose death was reported recently at the age of 42 years, was a director of the Blyth Shipbuilding & Dry Docks Company, Limited.

Mr. R. R. Penman, Newlyn, Circus Drive, Dennistoun, chairman and managing director of Penman & Company, Limited, Caledonian Boiler Works, 64, Strathclyde Street, Glasgow, died recently.

Mr. A. L. Sabine, late secretary to Siemens Brothers & Company, Limited, of Woolwich and Dalston, died on February 20. He was secretary of the company from 1880 to 1910, retiring in the latter year after 50 years' service.

Mr. T. Stevenson, of the firm of T. & J. Stevenson, engineers, Kilmarnock, died on February 18. He served his apprenticeship with Messrs. Young, engineers, Ayr, and many years ago began business in Kilmarnock in partnership with his brother, first in Sandbed Street and latterly in New Mill Road.

Mr. Wells Hood, civil engineer, has died at his residence, Addison Mansions, West Kensington, London, W. The deceased started his engineering career under Mr. T. Cabry and Mr. E. Wilson, in the engineering and locomotive department of the North-Eastern Railway, and afterwards he was connected with numerous railway projects in this country and abroad.

Mr. C. H. Churchill, managing director of Charles Churchill & Company, Limited, has died at the age of 52 years. He had been associated with the firm for 33 years, and represented the importers on the Machine Tool Committee of the Ministry of Munitions. The death has also taken place of Mr. Charles Churchill, the founder of the firm and senior director.

Mr. Henry Parker, a Birmingham magistrate, died very suddenly on February 21. The deceased, who was a member of the firm of Parker, Winder & Achurch, ironfounders, was appointed to the Commission of the Peace only two years ago, but he had rendered public services in many other directions. He was 70 years of age.

Lieut. A. R. Welsh, 4th Yorkshire Regiment (T.F.), who is reported to have died of wounds received in action, was the secretary of Bell Brothers, Limited, of Middlesbrough, until at the outbreak of war he received a commission in the local Territorial Battalion. Lieut. Welsh was formerly a member of the staff of Mather & Platt, Limited, of Manchester.

The death occurred at Fern Bank, Haslingden, on February 19, of Mr. John Chew, aged 64. As a lad he went to work at Messrs. S. S. Stott's Laneside Foundry, Haslingden, and ultimately became manager there. He had been with the firm for 46 years, and general manager for a large portion of that period. On his retirement in 1913 the workmen presented him with a silver rose bowl. He was a Past Master of the Amity Lodge of Freemasons, Haslingden. He served on the old Technical Instruction Committee of the Haslingden Town Council and on the present Higher Education Committee.

The death has taken place at his residence, Belmont, Norfolk Road, Sheffield, of Mr. Herbert Beesley, at the age of 52 years. The deceased was connected with his father in business from the time when the latter started the Universal Steel Works, Wire & Rolling Mills in Sheffield many years ago. About 30 years ago Mr. W. T. Beesley, the father, formed his business into a private limited company, under the style of W. T. Beesley & Company, Limited, and this company and Colver Brothers, Limited, became amalgamated with Sir Joseph Jonas Colver & Company, Limited, then Jonas & Colver, Limited. Mr. Herbert Beesley became the secretary of W. T. Beesley & Company, Limited, and afterwards also a director and managing director. When failing health a few years ago caused Mr. W. T. Beesley to resign his permanent directorships in the three companies, he appointed Mr. Herbert Beesley to succeed him, and the latter held these permanent directorships at the time of his death. He resigned the position of managing director of W. T. Beesley & Company, Limited, two years ago on account of failing health.

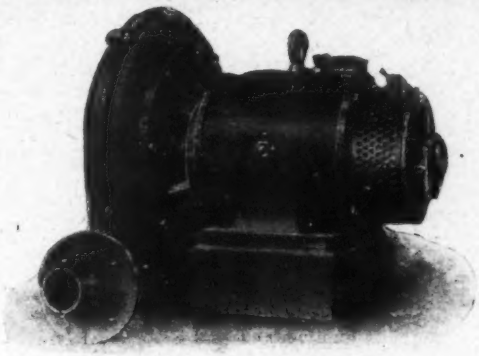
The death is reported of Mr. George Hailstone, a well-known Birmingham metallurgist. Mr. Hailstone, who was born in 1883, was educated at Tindal Street Board School and the Municipal Technical School, Birmingham, and was assistant in the Metallurgical Department of the Technical School from 1899 to 1902, and Demonstrator in Metallurgy from 1902 to 1905. In 1905 he was appointed chemist and metallurgist to W. & T. Avery, Limited, Soho Foundry, Birmingham. At the time of his death he had for about 15 months occupied a similar position with the Giles Foundry & Rudge-Littley, Limited, Swan Village, West Bromwich. Mr. Hailstone's research work was concerned mainly with cast-iron, and he attained special distinction by the work he did on liquid contraction. His first investigation of this subject was commenced in association with Mr. F. J. Cook. Mr. Hailstone's work on liquid contraction in cast-iron secured for him in 1911 a Carnegie Research Scholarship of the value of £100 to enable him to follow up the investigation. The scholarship was renewed in the following year, with a grant of £50 so that he might complete the work, which was brought to a conclusion in 1914. Papers on cast-iron were given by Mr. Hailstone before the British Foundrymen's Association, to the Birmingham branch of which he acted for a time as secretary, and various other societies. His published papers include: "The Characteristics of Foundry Irons," "The Action of the Metalloids on and the Microstructure of Foundry Irons," "The Sampling of Pig-iron," "The Scientific Mixing of Iron for Castings," "The Work of an Iron Foundry Laboratory," "The Microscopic Analysis of Cast-iron," and "The Use of the Microscope in Foundry Practice." He was also joint author with Mr. F. J. Cook of a research on "The Effect of Structure on the Physical Properties of Cast-iron."

Applications for Patents.

An asterisk indicates that a complete Specification accompanies the application. When inventions are communicated the names of the communicators are in brackets.

For convenience of reference, the Applications are arranged alphabetically under the names of the applicants and communicators, the latter being printed in Italic type. In the case of joint applicants or communicators, each name is given independently. The subject entry is an abridgment of the title only, and should not be regarded as an exhaustive subject-matter entry. The number after the subject entry is that of the Application, and should be used for correspondence purposes up to the date of acceptance of the Complete Specification. A new number will be given when the Complete Specification is accepted, or becomes open to public inspection before acceptance; in all proceedings after acceptance this new number only should be employed. The date following the Application number is that on which the Application was filed; the date which the Patent will bear, if granted, will appear in a subsequent list of Complete Specifications Accepted.

Chandler, D. Gas furnaces. 10. Jan. 3. Crucibles to be used with gas furnaces. 176. Jan. 5.
Drake, W. A. Regenerative furnaces. 7. Jan. 3.
Drakes, Ltd. Regenerative furnaces. 7. Jan. 3.
Fixter, J. T. Apparatus for casting slag bricks. 61. Jan. 3.
Kitching, T. Apparatus for casting slag bricks. 61. Jan. 3.
Mair, W. B. Casting metals. 366. Jan. 8.
Mellen, G. Automatic metal feed for continuous casting machines. 323. Jan. 7. Guides for continuous casting-machines. 324. Jan. 7.
Mitchell, A. H. Hoisting appliances. 5. Jan. 3.
Price, C. F. Furnaces for melting metal for brass castings, etc. 215. Jan. 6.
Ridley, T. W. Apparatus for casting slag bricks. 61. Jan. 3.
South Metropolitan Gas Co. Gas furnaces. 10. Jan. 3. Crucibles to be used with gas furnaces. 176. Jan. 5.



10 H.P. Fan and Motor.

TRADE SIROCCO MARK

High Pressure Fans

Are made in a large number of sizes from 10 in. diameter upwards.

Bulletins 2000 F. and 2028 F.

Some Points worth noting.

Owing to few wearing parts, the Fans are not liable to break down. The mechanical efficiency is high and remains so. The pressure is steady and the volume even and free from pulsations.

Davidson & Co., Ltd.,

Sirocco Works,
BELFAST.

ELDER'S FOUNDRY COKE

AS SUPPLIED TO THE
BRITISH
ADMIRALTY DOCKYARDS.

The following, selected from numerous letters, are eminent testimony as to the quality of our celebrated "A.A.A." Coppee Foundry Coke, carefully selected and despatched in sheeted wagons.

From PECKETT & SONS, Bristol.

Bristol, October 25th, 1901.

We have been using your Selected Foundry Coke for some considerable time.
We have pleasure in stating that we are very pleased with it, as we find we get sounder and cleaner castings, more free from blowholes and other defects, than we formerly did.

From BOW, McLACHLAN & CO., LTD. (Paisley Foundry), Paisley, Glosgow.

Paisley, 12th March, 1909

Oe have yours of 4th inst., and ic reply have pleasure in stating that we have been using your Foundry Coke for several years for special purposes with highly satisfactory results.

Celtic Collieries, Ltd., Cardiff.

Telegraph: "OUTPUT, CARDIFF." Telephone: 4740 & 4641.

New Companies.

Dudley Foundry Company, Limited.—Capital £10,000 in £1 shares.

Lidgett Engineering Company, Limited.—Capital £5,000 in £1 shares (1,500 preferred).

J. F. Farwig & Company, Limited.—Capital £25,000 in £1 shares, to carry on the business of iron-workers, etc.

Premier British Lead Products Company, Limited.—Capital £15,000 in £1 shares. Registered office: 51-2, Fenchurch Street, E.C.

Regulus Metal & Plumbing Company, Limited.—Capital £10,000 in £1 shares. Registered office: Birch Street, Wolverhampton.

Smallware Manufacturers, Limited.—Capital £1,000 in £1 shares, to carry on the business of brassfounders, &c. Registered office: 37, Tenby Street, Birmingham.

Luby-Lowe Engineering Company, Limited.—Capital £6,000 in £1 shares (3,000 7 per cent., participating preference. Registered office: 31, Queen's Road, Bristol.

Charles Bruce & Company, Limited.—Capital £15,000, in £1 shares, to carry on the business of ironfounders, &c. Registered offices: Pinner's Hall, Old Broad Street, E.C.

Topping Brothers, Limited.—Capital £2,000 in £1 shares, to carry on the business of boiler makers, engineers, etc., at Gibbons Street, Bradford, Manchester, as Topping Brothers.

Makin & Company, Limited.—Capital £1,000 in £1 shares, to carry on the business of electrical and mechanical engineers and manufacturers. Registered office: 39, Townhead Street, Sheffield.

Harrison Brothers (England), Limited.—Capital £6,000 in £1 shares, to take over the business carried on by Harrison Brothers at Atlas Foundry, Middlesbrough. The first directors are A. Edwards, A. C. Cronk and T. B. Kitson.

Forth Shipbuilding & Engineering Company, Limited.—Capital £100,000 in £1 shares, to adopt an agreement with W. Hine, which is supplemental to an agreement between W. Hine and J. Constant, and to acquire the Kellybank Shipbuilding Yard, Alloa.

Croft & Perkins, Limited.—Capital £1,000, in £1 shares, to carry on the business of mechanical engineers, manufacturers of engines, etc., as a branch of Crofts (Engineers), Limited, who are the controllers of the company. Registered office: Empire Works, Thornbury, Bradford.

Scott, Kirk & Company, Limited.—Capital £1,000, in £1 shares, to carry on the business of general mechanical and electrical engineers, etc. The first directors are: M. Scott and H. H. Green. Registered office: Montgomery Works, Rockingham Street, Sheffield.

Russell Brothers & Company (Wolverhampton), Limited.—Capital £1,500 in £1 shares, to take over the engineering business carried on by A. M. Russell at Cleveland Street, Wolverhampton, as Russell Bros. and Company. Registered office: 33A, Cleveland Street, Wolverhampton.

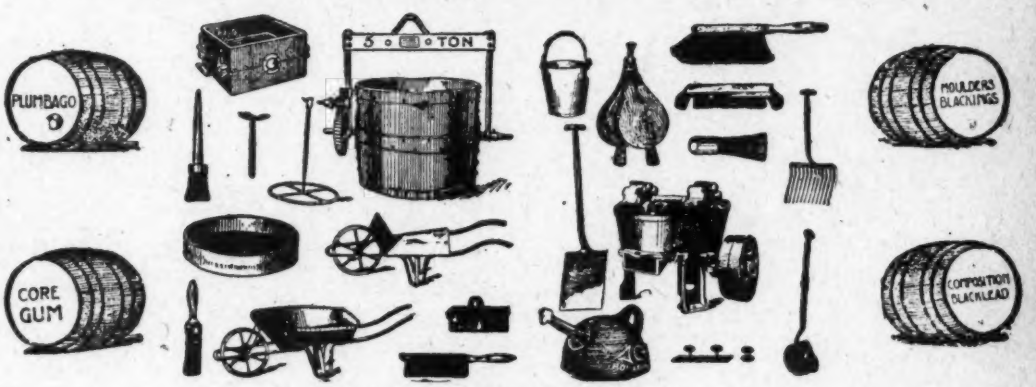
The Lidgett Engineering Company, Limited.—Capital £5,000 in £1 shares (1,500 preference), to take over the business of a mining, electrical and mechanical engineer carried on by Mr. G. F. Steavenson, as Steavenson & Company, at Lidgett Electrical Engineering Works, Hoyland Common, Barnsley. The first directors are G. S. Marple and G. F. Steavenson.

Fellows Brothers, Limited.—Capital £30,000 in £1 shares, to take over the businesses of a manufacturer of chains, cables, and anchors, carried on by J. Fellows, at Clyde Works, Cradley Heath, as Fellows Brothers, and that of an engineer and ironfounder carried on by J. Fellows, at Corngreaves Works, Cradley Heath, as the Mid-British Company.

Established 1863.

JAS. DURRANS & SONS,

Phœnix Works, Penistone, Near Sheffield.



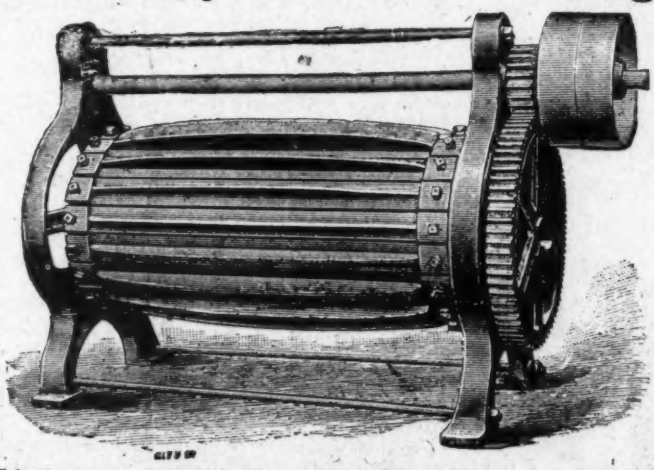
Manufacturers of all

FOUNDRY EQUIPMENTS

COMPOSITION BLACK LEAD, PLUMBAGO, CORE GUM, WHITE DUST & COAL DUST

Ladles, Cupolas, Fire Bricks, Gannister, Stone Flux, Loam and Sand Mills, Casting Cleaners, Studs, Chaplets, Pipe Nails, Sprigs, Brushes, Wire Brushes, Core Ropes, Bellows, Buckets, Spades, Forks, Riddles, Sieves, Barrows, Etc.

Improved Foundry Rattler or Fettling Drum.



These Machines are invaluable for a Foundry, doing a larger amount of work of a superior quality, in a much shorter time than can be done by hand, without skilled labour.

The following testimonial explains itself :—

"Dear Sirs,—We have been using your best Blacking for a large number of years, and always use it on our large Ingot Moulds, which, as you know, we have made up to 85 tons in weight.

Yours faithfully, THE BRIGHTSIDE FOUNDRY & ENGINEERING CO., LD.

MONTHLY PRICE LIST.

The undermentioned prices, unless otherwise specified, are those obtaining at the commencement of the current month.

Pig-Iron.

Cleveland.

	s.	d.
Cleveland No. 1	91	6
,, No 3	87	6
,, No. 4 foundry	86	6
,, No 4 forge	85	6
,, Mottled	—	
,, White	—	
East Coast hematite, mixed Nos. ..	140	0
Cleveland warrants	86	9

Above prices are for early f.o.b. deliveries and as regards Cleveland iron are for G.M.B. brands. The warrant quotations are the sellers' cash prices.

Scotland.

	s.	d.
Standard Foundry (Glasgow Market settlement price)	85	7½
Warrants, ditto	92	0

Makers' prices :—

	s.	d.		s.	d.
Gartsherrie No. 1	127	6	No. 3	120	0
Coltness No. 1	141	0	No. 3	121	0
Summerlee No. 1	125	0	No. 3	120	0
Langloan No. 1	130	0	No. 3	125	0
Calder No. 1	122	6	No. 3	117	6
Clyde No. 1	122	6	No. 3	117	6
Carnbroe No. 1	115	0	No. 3	110	0
Monkland No. 1	115	0	No. 3	114	0
Shotts No. 1	127	6	No. 3	120	0
Govan No. 1	118	6	No. 3	112	6

(All deliverable alongside Glasgow.)

Glengarnock	No. 1	117	6	No. 3	112 6

(Deliverable alongside Ardrossan.)

Dalmellington	No. 1	121	0	No. 3	119 0
Eglington	No. 1	120	0	No. 3	118 0

(Deliverable alongside Ayr.)

Carron	No. 1	—		No. 3	—

(F.a.s. Grangemouth.)

Scotch hematite, f.o.t. steelworks 137 6

Lancashire.

	s.	d.	s.	d.
Lancashire No. 3 foundry f.o.t.	—		—	
Lincolnshire No. 3 foundry ..	—		—	
Derbyshire No. 3 foundry ..	92	3	92	6
Staffordshire No. 3 foundry	92	6	—	
Cleveland No. 3 foundry	—		—	

(All delivered equal Manchester.)

Scotch No. 3	Gartsherrie ..	122	6	127	6
	Glengarnock ..				
	Eglington ..	—		—	
	Summerlee ..	—		130	0

(Delivered Manchester Docks.)

North-West of England.

	s.	d.	s.	d.
Bessemer mixed numbers net f.o.b.	—		127	6
Hematite warrants net cash ..	—		115	0
Lorn cold-blast charcoal iron	—		—	

The Midlands.

		s.	d.	s.	d.
Staffs.	Part Mine forge ..	87	6	90	0
	Best All Mine ..	—		150	0
	Cold Blast	—		170	0

Strong forge, about 1s. less than grey forge; Mottled and White, about 2s. less than forge; Foundry No. 3, 3s. to 5s. above forge; No. 1 and No. 2, from 1s. 6d. to 2s. above No. 3; No. 1, about 2s. above No. 2.

Northampton foundry ..	—		88	6
North Staffs. foundry ..	—		—	
Derby foundry ..	—		95	0
Nottinghamshire foundry ..	—		—	
Leicestershire foundry ..	—		93	0
Shropshire Cold-Blast ..	—		170	0

(Delivered South Staffordshire Works, net cash monthly.)

Lincolnshire.

	s.	d.	s.	d.
Forge	—		91	0
Grey forge	—		91	0
Basic	—		—	
No. 3 foundry	—		92	0
No. 4 foundry	—		—	

F.o.t. Makers' Works.

South Wales.

	s.	d.	s.	d.
Welsh Hematite	—		Nom.	

Ferro-Alloys.

Net, Delivered Sheffield steel works.

	£	s.	d.
Ferro chrome : 4/6% carbon. Basis 60%, scale 10s. per unit. Per ton	35	0	0
Ferro-chrome : 6/8% carbon. Basis 60%, scale 10s. per unit. Per ton	29	10	0
Ferro-chrome : 8/10% carbon. Basis 60% scale, 10s. per unit. Per ton	28	0	0
Ferro-chrome : Specially refined, guaranteed maximum 2% carbon, broken to small pieces for use in best quality crucible steels. Basis 60%, scale 32s. per unit. Per ton	86	0	0
Ferro-vanadium : 33/40% Va., perlb. of Va. contained in the alloy ..	0	14	0
Ferro-silicon : 45/50%. Basis 50%, 5s. scale per unit .. Per ton	27	10	0
Ferro-titanium : 23/25%, per pound carbonless	0	1	9
Ferro-molybdenum : 70/80% Mo. per pound of Mo. contained ..	0	18	0
Ferro-phosphorus : 20/25%. Per ton	16	10	0
*Ferro-manganese 80%	25	0	0
,, export	—		

* F.o.b. Liverpool.

Iron Castings.

Cleveland.

	£	s.	d.	£	s.	d.
Columns (plain) ..	—			to	—	
Pipes, 1¼ to 2½ in. ..	—				—	
,, 3 to 4 in. ..	—				—	
,, 5 to 8 in. ..	—				—	
,, 10 to 16 in. ..	—				—	
,, 18 to 24 in. ..	—				—	
Chairs	—				—	
Floor plates (open sand)	—				—	

(At work.)

Non-Ferrous Metals.

Copper.

	£	s.	d.	£	s.	d.
Standard, Cash ..	102	10	0	102	15	0
Three months ..	101	0	0	101	10	0
Electrolytic ..	135	0	0	137	0	0
Tough	126	0	0	128	0	0
Best selected ..	127	0	0	129	0	0

Tin.

	£	s.	d.	£	s.	d.
Standard, Cash ..	189	10	0	189	15	0
,, Three months	189	0	0	189	5	0
English Ingots ..	191	0	0	192	0	0
Bars	192	0	0	193	0	0
Refined	196	0	0	197	0	0

Spelter.

American	—	95	0 0
Specials	—	—	
Hard	—	75	0 0
British	—	96	10 0

Lead.

Soft Foreign	—	33	10 0
English	—	34	5 0

Antimony.

Regulus	—	95	0 0

Aluminium.

Virgin Metal 98/99% per ton	155	0 0	200 0 0

*Chromium (Metallic).

98/99% purity, per lb.	—	—

*Nickel.

In cubes, 98/99% purity Per ton	220	0	0

*Tungsten Metal Powder.

96/98% purity .. per lb. ..	0	5	10

*Molybdenum Metal.

96/98% purity .. per lb. ..	—

*Cobalt Metal.

97% purity .. per lb. ..	0	8	0

Quicksilver.

75 lb. bottle	16	13	9

* Net, Delivered Sheffield Works.

Scrap Iron and Steel.

Cleveland.

	s.	d.	s.	d.
Steel scrap, heavy melting ..	97	6	to 100	0
Iron scrap cast (cupola metal)	75	0	77	6

London (f.o.b.).

Heavy steel	80	0	
Light ,, ...	50	0	
Heavy cast	80	0	

Non-Ferrous Scrap.

London merchants quote the following prices for scrap metal, delivered London, and subject to market fluctuations :—

	A. Joseph. £	s.	d.
Hy. Electrolytic Copper Scrap ..	117	0	0
Hy. Selected Scrap Brass ..	76	0	0
Hy. Tinned Copper Wire ..	105	0	0
Best Selected Gunmetal Scrap ..	96	0	0

Re-melted Ingot Lead 40s. under English Lead price on date of order.

Stocks.

Pig-Iron in Public Store.

	Mar. 9. Tons.	Inc. + or Dec. – since Mar. 11 1915. Tons.
Connal's at Glasgow Scotch	1,000	No change.
Ditto other makes ..	—	No change.
Connal's at Middlesbrough	77,410	– 47,841
Connal's at Middlesbrough hematite ..	—	No change.
West Coast hematite	1,846	– 2,290

Metals.

Copper, Europe and afloat	21,734	– 13,391
Tin, London, Holland, U.S.A. and afloat	18,166	+ 1,324

Coke.

Middlesbrough.

	s.	d.	s.	d.
Gas Coke	—		29	0
Foundry Coke	45	0	50	0
Furnace Coke	—		30	6

Newcastle-on-Tyne.

	F.o.b. Dunston. s.	d.	s.	d.
FOUNDRY COKE—				
Original Garesfield ..	—		45	0
Mickley	—		45	0
Stella Garesfield	—		45	0
Priestman's Garesfield ..	—		45	0
Consett Garesfield ..	—		45	0
Newcastle gas coke ..	—		28	0

Cardiff.

	s.	d.	s.	d.
Special Foundry Coke ..	50	0	to 52	6
Foundry Coke	47	6	to 50	0
Furnace Coke	36	0	to 40	0

Leeds.

Furnace Coke (washed) ..	—	24	0

Birmingham.

Foundry Coke	—	—	
Furnace Coke	—	—	
Gas Coke	27 0	29	0

Glasgow.

Foundry Coke	—	36	0
Furnace Coke	26 0	27	0
Gas Coke	—	—	

London.

Welsh or Durham Foundry, d/d London Stations, in truck	—	52	0
Ditto, d/d Birmingham Stations	—	48	0
Yorkshire, d/d London Stations, in truck ..	—	44	0
Ditto, d/d Birmingham Stations	—	40	0

SITUATIONS VACANT AND WANTED.

FOUNDRY FOREMAN, disengaged, used to all classes of work, light and heavy; green sand, dry sand; fair knowledge of loam; experience in non-ferrous metals; age 42.—Write, Box 602, Offices of *Foundry Trade Journal*, 165, Strand, W.C.

TRAVELLER calling on Iron Founders, Lancashire, offers to sell Pig-iron for Derbyshire or Staffordshire Makers.—Address, Box 386, Offices of *Foundry Trade Journal*, 165, Strand, W.C.

FOR SALE AND WANTED.

GANISTER for Cupolas, Furnaces, etc. Very best quality. On War Office List. Supplied to all leading Iron Works and Foundries. Established 30 years.—Astbury Silica Company, Newbold, Astbury, near Congleton (late Sankey & Hall). Communications to D. Boulton, Astbury Silica Company, Kidsgrove, Stoke-on-Trent.

SAND MILL FOR SALE, in excellent condition; 4 ft. deep pan; "Rapid" type.—Address, Box 600, Offices of *Foundry Trade Journal*, 165, Strand, W.C.

COMPLETE TROPENAS STEEL PLANT FOR SALE.

COMPLETE TROPENAS STEEL PRODUCING PLANT, consisting of Cupola capable of melting 10 tons per hour, with Waygood Electric Hoist, Staging, and steam-driven Roots Blower; 2 2-ton Converters with electric tilting gear, and very fine Steam Twin Cylinder Air-blowing Engine; Lancashire Boiler, by Galloway, Limited, Manchester, 30 ft. by 8 ft., 160 lbs. working pressure, with Gauges, Pipes and Mountings; also 4 3-ton and 2 9-ton Lip Pouring Ladles. The plant is now in operation, and is offered for delivery in, approximately, six months. It is capable of producing 25 tons of steel per 10-hour day, and is suitable for making castings up to 10 tons in weight.—For further particulars, apply to No. 596, Offices of *Foundry Trade Journal*, 165, Strand, W.C.

FOR SALE AND WANTED—*continued.*

FOR SALE.—24-in. Invincible Sand Mixer, capacity 3 tons per hour, for grinding, mixing and screening foundry sands, at lowest cost per ton.—Apply, HALL, 26, Paradise Square, Sheffield.

FOR SALE, Flat Table HYDRAULIC MOULDING MACHINE, for boxes 50 in. by 27½ in., and 42 Moulding Boxes for same; Flat Table Hydraulic Moulding Machine, for boxes 26 in. by 21½ in., and 78 Moulding Boxes for same; Patent Horizontal Sand Mixer, 3 to 4 tons per hour. All by London Emery Works Company. Equal to new.—Address, Box 598, Offices of *Foundry Trade Journal*, 165, Strand, W.C.

PATTERN SHOP SUPPLIES.

Wires: "Requisites, B'ham." **J. BURN & CO.,** 'Phone: 137 Victoria.

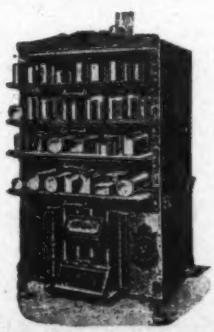
Henshaw Road, Small Heath, BIRMINGHAM.

ARE YOU INTERESTED IN THE PRODUCTION OF CHEAP, ACCURATE CASTINGS?

We Specialise in :: MOULDING MACHINES, PATTERN PLATES, MOULDING BOXES, SNAP FLASKS, etc. :: ::

ADAPTABLE MOULDING MACHINE CO., Stanhope St., BIRMINGHAM

Telegrams: "ADAPTABLE." 'Phone: 1966 Mid.



THE "PORTWAY"

PORTABLE CORE OVENS

For Gas or Fuel.

TESTIMONIAL.

From The Braintree Castings Co.,
Chapel Hill Foundries, Braintree, Essex.

Gentlemen,

We are very pleased with the Core Oven we recently purchased from you. We find it dries the cores quickly without burning them. It is very handy and economical to use and is altogether superior to other ovens of this type we have in use.

Will you please quote us your best price for four more like it,

Yours faithfully,
For The Braintree Castings Co.,
(Signed) W. B. LAKE, Director.

Makers: **C. PORTWAY & SON,** TORTOISE STOVE & PORTWAY PORTABLE OVEN WORKS, **HALSTEAD, ESSEX.**

PLUMBAGO—CRUCIBLES.

Parting Powder.

William OLSEN,
Cogan Street, HULL.

FOUNDRY MATERIALS AND REQUISITES.

Largest Stock of Straw and Wood Fibre CORE ROPINGS.

Wax Core Vent.

GLUTRIN—CORE GUM.

FOUNDRY PLANT MACHINERY FOR SALE.
BARGAINS FOR PROMPT CASH.

Root's Blower, with high-speed Vertical Engine combined.
Thwaites' Roots Blower, 11½" discharge.
4' dia. Impeller Lloyd's Blast Fan, for 100 smiths' fires.
14" Schiele patent Blast Fan.
Lloyd's patent Blowing Fan for 50 smiths' fires.
Ball Mill, with drum, 2' 7" and 5' 8" outside by 1' 7" wide.
Improved Foundry Core Ovens, portable type, and for fixing in wall.
4' 6" dia. UNDERGEARED LOAM MILL, with stationary pan.
ENGINES and BOILERS and all classes of MACHINERY, good second-hand. In stock ready for immediate delivery.

CHARLES D. PHILLIPS,
EMLYN & CENTRAL ENGINEERING WORKS, NEWPORT, MON.

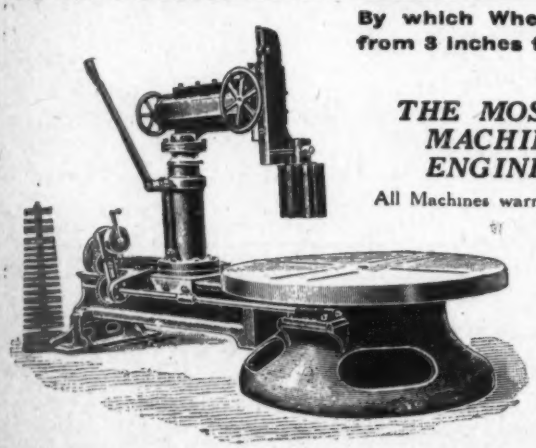
38¼
McNEIL'S
PATENT UNBREAKABLE
STEEL LADLES
These Ladles are manufactured by a patented process, each from a single steel plate without weld or rivet. They are extremely light, being at the same time the strongest and most durable in the market. Ladles to contain 56 lb. of metal only weigh about 7 lb. each. They are made of all capacities from 30 lb. to 60 cwt., with or without lips; also mounted or unmounted. They are also suitable for chemical and metallurgical processes. List of sections and prices on application to
CHAS. McNEIL.
KINNING PARK IRONWORKS,
GLASGOW
30"
32½"

CAN ALSO BE MADE IN ALUMINIUM.

Kindly mention this paper when enquiring or ordering.

WHITTAKER'S IMPROVED MOULDING MACHINE

By which Wheels or Pulleys of any description or size from 3 inches to upwards of 20 ft. diameter can be made.



THE MOST COMPLETE AND EFFICIENT MACHINE HITHERTO INTRODUCED TO ENGINEERS.

All Machines warranted to Mould with the greatest accuracy and precision.

GEARING WHEELS

Spur or Bevel, Straight Teeth and Double Helical Teeth Supplied to Consumers.

ROPE & BELT PULLEYS.

WM. WHITTAKER & SONS, LTD.,

SUN IRON WORKS, ***OLDHAM.***

Index to Advertisers.

Addresses, Telegraphic Addresses, and Telephone Numbers.

PAGE.	NAME.	ADDRESS.	TELEGRAPHIC ADDRESS.	TELEPHONE NO.
220	Adaptable Moulding Machine Co.	Stanhope Street, Birmingham	"Adaptable"	1968 Mid.
	Alldays & Onions, Ltd.	Birmingham	Alldays, Birmingham	28 Victoria
179	Anglo-Mexican Petroleum Products Co., Ltd.	Finsbury Court, Finsbury Pavement, E.C.	Mexproduct, Ave, London	City 2704
179	Braby, F. & Co., Ltd.	Petershill Road, Glasgow	Braby, Glasgow	—
C. iii.	Bradley, T. & I. & Sons, Ltd.	Darlaston	Bradley, Darlaston	—
178	Britannia Foundry Co.	Coventry	Stoves, Coventry	251
174	British Binderit Co., Ltd.	Wharf Road, Wandsworth, S.W.	Bindercomp, Wands., London	994 Putney
C. ii.	British Thermit, Ltd.			
181	Broadbent, T. & Sons	Huddersfield	Broadbent	1581 (4 lines)
C. iv.	Buckley & Taylor, Ltd.	Castle Iron Works, Oldham	Engines, Oldham	Oldham No. 8
223	Burn, J. & Co.	Small Heath, Birmingham	"Requisites," Birmingham	137 Victoria
219	Celtic Collieries, Ltd.	Cardiff	Output, Cardiff	4640-1 Cardiff
C. ii	Cumming, William & Co., Ltd.	Maryhill, Glasgow	Prudence, Glasgow	P.O.M. 25
219	Davidson & Co., Ltd.	Belfast	Sirocco, Belfast	4341 Belfast
171	Davies, T. & Son	West Gorton, Manchester	Tuyere, Manchester	70 Openshaw
221	Durrans, Jas. & Sons	Penistone, nr. Sheffield	Durrans, Penistone	—
217, 182	Evans, J. & Co.	Manchester	Ladles, Manchester	2297
178	Everitt & Co.	40, Chapel Street, Liverpool	Persistent, Liverpool	1134 Central (3 lines)
178	Fyfe, J. R., & Co.	Shipley, Yorks	Brick, Shipley	59 Shipley
	Glasgow Patent Moulders Blacking Co.	26, Fleming St., Port Dundas, Glasgow	Moulders, Glasgow	—
170	Goldendale Iron Co., Ltd.	Tunstall, Stoke-on-Trent	Goldendale, Tunstall, Staffs	—
180	Gray, Thomas E. & Co.	3—4, Lincoln's Inn Fields, Kingsway, London, W.C.	Papplewick, Holb, London	1946 Holb.
178	Hall, John & Co. (Stourbridge), Ltd.	Fire Clay Works, Stourbridge	Hall, Stourbridge	55 Stourbridge
177	Hedley Moorwood & Co., Ltd.	21, Church Street, Sheffield	Morod, Sheffield	4318
	Hislop, R. & G.	Paisley	Gas, Paisley	331 Paisley
175	Keith, James & Blackman Co., Ltd.	27, Farringdon Avenue, London	James Keith, London	6194 H'lb'rn (4 lines)
181	King Bros. (Stourbridge), Ltd.	Stourbridge	King Bros., Stourbridge	—
	London Emery Works Co., Ltd.	Prak, Tottenham	Naxium, London	9 Tottenham
169	Lowood, J. Grayson, & Co., Ltd.	Deepcar, nr. Sheffield	Lowood, nr. Sheffield	18 Stocksbridge
224	Mansergh, T. E.	Wheathill Charcoal Works, Salford	—	—
	Marshall, H. P. & Co.	Leeds	Speciality, Leeds	1909 Leeds
	Metalline Cement Co.	112, Bath Street, Glasgow	Adhesive, Glasgow	201Y2 Douglas
224	McNeil, Chas.	Kinning Park, Glasgow	McNeil, Glasgow	X 155
C. i.	Muir, John & Son	Beith, N.B.	Muir, Beith	Nat. No. 37
173	Naish & Croft	150, Alma Street, Birmingham	—	—
224	Olsen, William	Cogan Street, Hull	Wm. Olsen, Hull	Nat. 1184
221	Phillips, Charles D.	Newport, Mon.	Machinery, Newport	—
C. iii.	Phillips, I. W. & C. J.	23, College Hill, E.C.	Colloquial, London	10112 Central
	Portway, Chas. & Son	Halstead, Essex	Portway, Halstead	10 Halstead
220	Rowlands, T. & Co., Ltd.	North Church Street, Sheffield	"Titanicum," Sheffield	Central 4904
172	Samuelson & Co., Ltd.	Banbury	Samuelson, Banbury	17 Banbury
181	Sankey, Joseph & Sons, Ltd.	Hadley, Salop	Sankey, Hadley	—
173	Stewart, D. & Co., Ltd.	London Road Iron Works, Glasgow	Stewart, Glasgow	71 P.O. Bridgton & 3243 Bridgton (N.)
175	Spermolin Core Co.	Spermolin, Halifax	Halifax	397
	Tilghman's Patent Sand Blast Co., Ltd.	Broadheath, nr. Manchester	Tilghmans, Altrincham	14
176	Thwaites Bros., Ltd.	Bradford	Thwaites, Bradford	3456 & 3460 Brdf'd
180	Universal Machinery Corporation, Ltd.	326, Old Street, London, E.C.	Toolcraft, London	3763 London Wall
173	Walker, I. & I.	Rotherham	—	—
	Walco, Ltd.	53, Newton Street, Birmingham	Walco, Birmingham	Central 3395
223	Westinghouse Cooper Hewitt Co., Ltd.	80, York Road, King's Cross, N.	—	—
224	Whittaker, W. & Sons, Ltd.	Oldham	Whittakers Engineers, Oldham	83
181	Wilkinson, Thos. & Co., Ltd.	Middlesbrough	Blacking, Middlesbro'	419
173	Williams, J. (Birmingham Sand), Ltd.	Birmingham	—	—

GANISTER, CUPOLA BLOCKS, FIRE BRICKS,

FIRE CLAY.

Silica Bricks, Tuyeres, Stoppers, Nozzles, &c.

STEEL MOULDERS' COMPOSITION, SILICA CEMENT.

J. GRAYSON LOWOOD & Co., Ltd.,

DEEPCAR nr. SHEFFIELD.

Telegrams: "LOWOOD, DEEPCAR."

GOLDENDALE CYLINDER PIG IRON.

MAKERS:

GOLDENDALE IRON CO.,

STOKE-ON-TRENT.

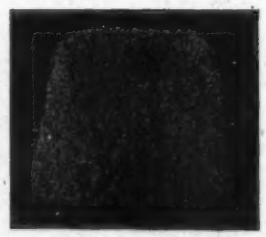
NOTE THE FOLLOWING POINTS—

1. Dense with close grey fracture.
2. Melts hot and exceedingly fluid and will fill every corner of your Mould.
3. Easy to Machine.
4. Absolutely sound.

WE MAKE A SPECIAL QUALITY FOR

MOTOR CYLINDERS.

Contractors to the Admiralty, Principal Railway Companies and Engineers at Home and Abroad.



Selling Agents: **WESTOBY & RAWSTRON,**

224, Corn Exchange Buildings, Hanging Ditch, MANCHESTER.

FOUNDRY CUPOLAS, LADLES.

And the

OSBORN'S PATENT CUPOLA

SPARK ARRESTER.

Are the Specialities of

T. DAVIES & SON,

RAILWAY WORKS, WEST GORTON, MANCHESTER.

ON ADMIRALTY LIST.

Telegrams—"TUYERE, MANCHESTER." Nat. Telephone—No. 70, OPENSHAW.

London Agents: MURPHY, STEDMAN & CO., Ltd., 180, Gray's Inn Road, London, W.C.

IMPORTANT TO IRONFOUNDERS.

MOULDING—
—MACHINES

FOR REPETITION FOUNDRY WORK.

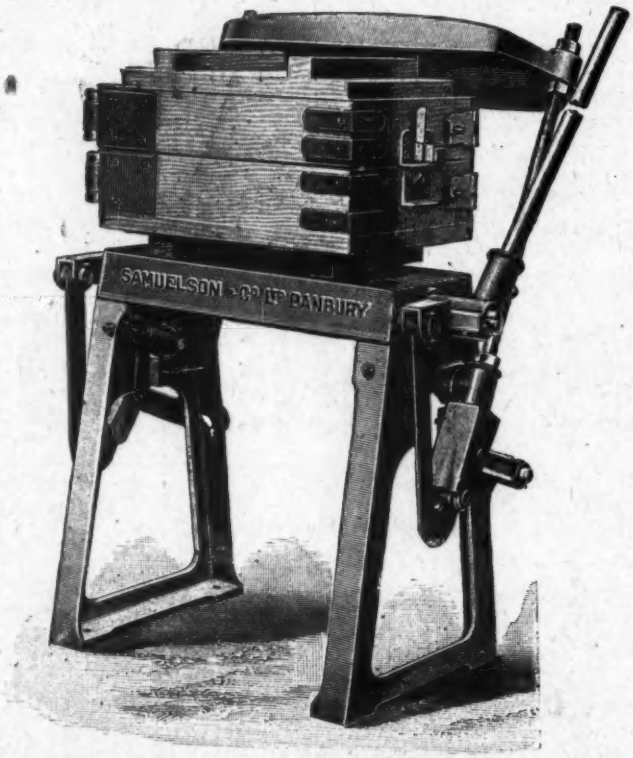


Illustration of

HAND PRESS MACHINE

for Small Repetition Work, giving rapid and Economical Production.

Makers also of a

HAND RAMMING MACHINE

where a Deep Lift is required. Can be Operated by

UNSKILLED LABOUR.

MOST EFFICIENT AND ECONOMICAL IN USE.

Also Makers - - of - - **ROOTS' "ACME" BLOWERS.**

FULL PARTICULARS FROM—

SAMUELSON & Co., Ltd., BANBURY, ENGLAND.

SEE OUR ADVERTISEMENT EVERY ALTERNATE MONTH.

ANALYSES

MECHANICAL TESTS and MICROGRAPHS

Consulting Metallurgists and Analytical Chemists.

— SPECIALISTS — IN FOUNDRY WORK.

Laboratory for all kinds of Metallurgical Investigations.

NAISH & CROFT,

150, Alma Street, BIRMINGHAM. | 24, University Mansions, Putney, LONDON, S.W.

JOHN WILLIAMS (BIRMINGHAM SAND), Ltd.

ICKNIELD SQUARE WHARF, BIRMINGHAM.

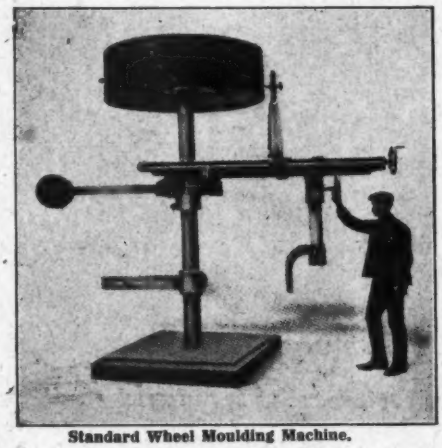
ESTABLISHED OVER A CENTURY.

SUPPLY

FOUNDRY SAND

To the Requirements of all Users.

Also ROLL SAND of all descriptions ready for use.



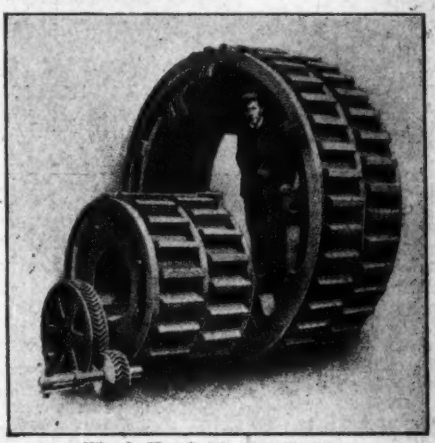
Standard Wheel Moulding Machine.

ALL IRON AND STEEL FOUNDRIES

SHOULD BE EQUIPPED WITH

STEWART WHEEL MOULDING MACHINES.

Complete Satisfaction Guaranteed



Wheels Moulded by this Machine.

No Loose Parts Liable to be Lost.

ACCURATE. PORTABLE. CHEAP.

WRITE FOR PRICE AND PARTICULARS TO

DUNCAN STEWART & CO., LTD.,

LONDON ROAD IRONWORKS, GLASGOW.

WE SUPPLY **THE** LEADING FIRMS IN THE TRADE WITH

FOUNDRY BLACKINGS

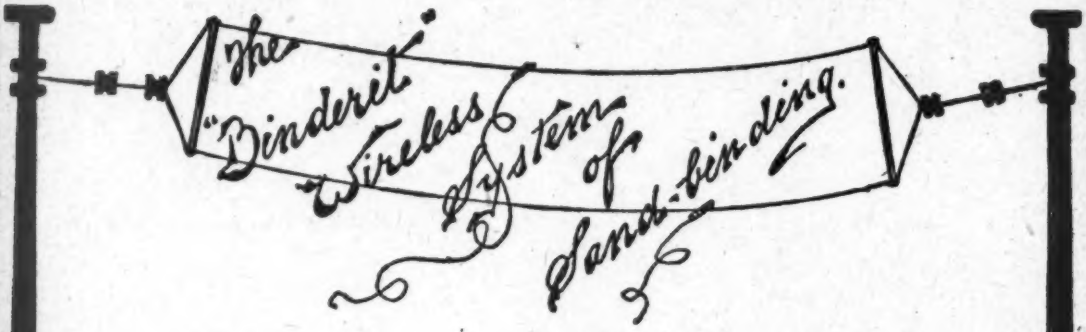
OF ALL KINDS

COAL DUST, CHARCOAL, PLUMBAGO and BLACK-LEAD CORE GUMS and all Foundry Requisites, and have done so since 1831.

I. & I. WALKER, EFFINGHAM MILLS, ROTHERHAM.

Our Specialite is Studying Special Requirements.

KINDLY HAND US YOUR ENQUIRIES.



"BINDERIT"

ALL BRITISH MADE

FOR USE IN THE FOUNDRY.

THE BRITISH BINDERIT Co., Ltd.,

is entirely **BRITISH.**

THE BRITISH BINDERIT CO. SPECIALISE IN THOSE REQUISITES WHICH ARE ABSOLUTELY NECESSARY FOR SUCCESSFUL CASTINGS PRODUCTION

"BINDERIT" is the sand binder of proved reliability and is the most economical and efficient sand binder extant.

"BINDERIT" supersedes all oil, oil compounds, gums or starches, and excels all other water soluble binders for cohesion and porosity.

"BINDERIT" is supplied in lump or liquid form, also as a powered core compound.

"BINDERIT" readily dissolves in cold water.

"BINDERIT" can be used with every kind or variety of sand and is used for sand mixes for steel, iron or non-ferrous castings.

"BINDERIT" reduces fettling charges to the minimum and practically eliminates the uses of wires or irons.

"BINDERIT" Silica or black-washes are of unrivalled excellence and superior to all others.

FOR FULL PARTICULARS AND PRICES APPLY TO—

THE BRITISH BINDERIT Co., Ltd.,
BINDERIT WORKS,
WHARF ROAD.
WANDSWORTH, S.W.

Binderit Trade Mark.

Telegrams:
"BINDERCOMP, WANDS., LONDON."

Telephone: 994 PUTNEY.

KEITH-BLACKMAN

High Pressure Fans.

Unequalled for heavy and continuous work.

Arranged for Belt or Electric-drive.

Extensively used for blowing
Cupolas, Furnaces,
Smithy Fires, etc.

James Keith & Blackman
Co., Ltd.,
27, Farringdon Avenue, LONDON.

THE ORIGINAL AND BEST CORE COMPOUND.

"SPERMOLIN"

(Registered Trade Mark.)

The Spermolin Core Company, Halifax. OR FROM:
JOHN SMITH & SONS, Old Hall Court, Newcastle-on-Tyne.

Telegrams—"SPERMOLIN, HALIFAX." *Telephone—397 Halifax*

FOUNDRY PLANT.

"Rapid" Cupolas,

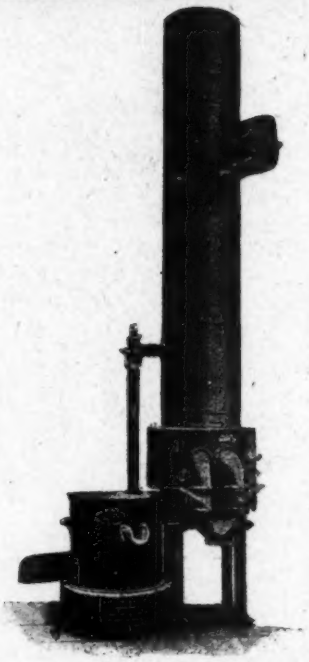
with or without receivers or drop bottoms.

Roots' Blowers,

belt, steam-engine, or electro-motor driven.

Charging Platforms,

Hoists, and Ladles.



ECONOMICAL RESULTS GUARANTEED.

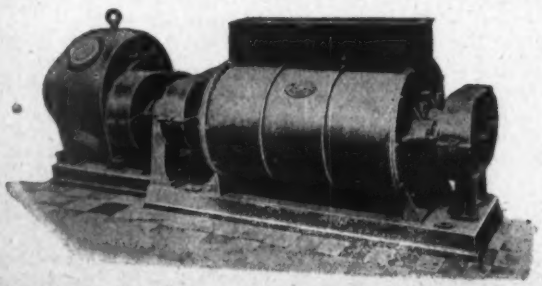
We are also Manufacturers of Steam Hammers, Smiths' Hearths, Centrifugal Pumps and Fans, High-Speed Engines and the "Bradford" Patent Boiler Feed Pump.

We are the original makers of "Rapid" Cupolas as under Stewart's Patent. We make this intimation as other makers are introducing this description, which had become established as a synonym of Stewart's Cupolas.

CONTRACTORS TO HIS MAJESTY'S GOVERNMENT.

THWAITES BROS., LTD.,

Vulcan Ironworks, BRADFORD.



Telegrams—
"THWAITES, BRADFORD."

Telephone—
Nos. 3459 and 3460 BRADFORD.

London Office:
96 & 98, Leadenhall Street, E.C.

Catalogues on Application.

"FOUNDRITE."

"FOUNDRYMEN have been seeking this material for years."

Supplied only in 40 gallon Casks. No bulk broken.

FOUNDRITE is another German speciality superseded and improved.

FOUNDRITE is **the** binding material for moulding sand and cores.

FOUNDRITE SUPERSEDES and makes unnecessary all classes of **CORE GUM, LINSEED OIL and all other BINDING material.**

FOUNDRITE will renew old and burned sand, making it usable over and over again.

FOUNDRITE makes **CORES** unbreakable and the use of **core irons** unnecessary.

FOUNDRITE leaves **CORES** perfectly porous and does **not shrink.**

FOUNDRITE has been **"found right"** for all **Sand binding** in the Foundry **for all purposes.**

FOUNDRITE is supplied in **LIQUID** form ready for use. Dilute with Water.

The porosity of the core is perfect, and cores so made do not shrink.

No blowing, cracking, crumbling, honeycombing, or loss of strength can take place.

COST OF USING "FOUNDRITE."

For ordinary work the price is about One Penny per gallon.

FOUNDRITE is used in all important Foundries in Great Britain and the Continent.

FOUNDRITE SAVES MONEY.

FOUNDRITE PREVENTS WASTERS.

Telegraphic Address—"MOROD, SHEFFIELD." **Telephone 4318.**

HEDLEY MOORWOOD & Co., Ltd.,

21, Church Street, SHEFFIELD.

FOUNDRY EXPERTS.

CUPOLA BRICKS

FOR LINING
ORDINARY AND PATENT
CUPOLA FURNACES.

JOHN R. FYFE & CO.,
SHIPLEY, Yorks.

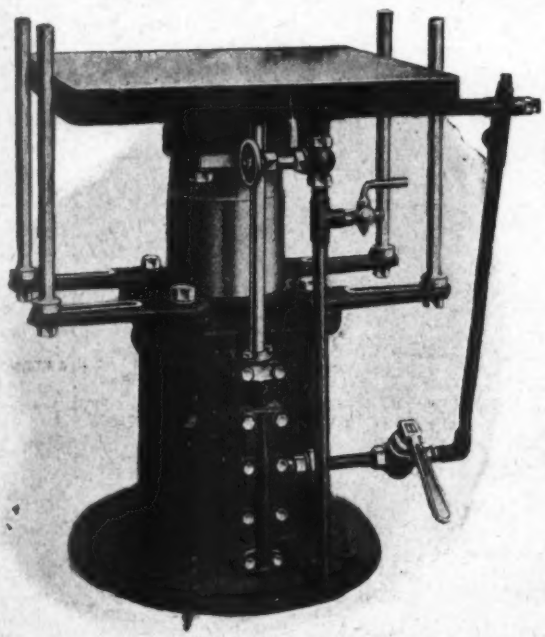
JOHN HALL & CO.

OF STOURBRIDGE, LIMITED.
STOURBRIDGE, ENGLAND.

Manufacturers of
FIRE BRICKS, BLAST FURNACE BRICKS AND CUPOLA BRICKS.

FERRO-VANADIUM. * * * * * **FERRO-TITANIUM.**
SILICO-MANGANESE { **23/30** % Silicon. **65/70** % Manganese and **1** %, **2** %, **3** %, Carbon Maximum.
FERRO-SILICON Containing **25** %, **50** %, **75** % Silicon.
FERRO-CHROME **65/70** % Cr. & **1** % up to **8/10** % Carbon Maximum.
ALUMINIUM **98/99** % Purity. *In Notched Bars and Half Round Sticks and Granular*
WE SUPPLY ALL CLASSES OF MINERALS, METALS AND METALLIC ALLOYS.

EVERITT & CO., 40 CHAPEL ST., LIVERPOOL.
Telegrams: "PERSISTENT." Telephone No. 1134 (3 lines).



"BRITANNIA" JAR RAM MOULDING MACHINE

(Daimler and Wardles Patent),
fitted with

SELF-CONTAINED LIFTING APPARATUS

Makers:
BRITANNIA FOUNDRY CO.,
Coventry.

London Agents: MURPHY, STEDMAN & CO., 180, GRAY'S INN ROAD, W.C.

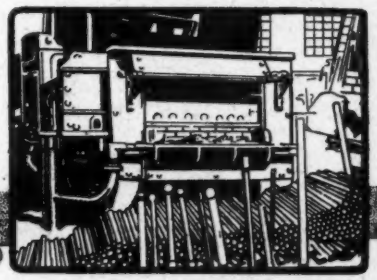
MEXICAN FUEL OIL

The use of Mexican Fuel Oil for industrial furnaces secures:—Increased Output—Saving in Time and Labour—Less Wastage of Metal —Higher Temperatures—Greater Control.

Anglo-Mexican Petroleum Products Co., LTD.

FINSBURY COURT, LONDON, E.C.

Write for illustrated booklet: "Heavy Fuel Oil Installations for Industrial Furnaces."



for INDUSTRIAL FURNACES

A NEW STEEL BARROW

(PATENTED).

"BRABY'S BALANCED BARROW."

The Handiest and Cheapest Barrow in the market. Specially designed for coal, dross, ashes, etc. Its capacity is 25 per cent. greater than the ordinary style, yet it can be wheeled with half the labour, and can be emptied much more quickly. It is a perfectly balanced barrow, and a full load can be easily wheeled by a boy.

NOTE.—This Barrow can be taken right up to mouth of furnace and the ashes drawn into the barrow direct from the furnace.

The "B.B.B."

BRABY for high grade **STEEL**
SHEETS and PLATES up to 15 FEET LONG.
RANGE OF GAUGES 8 to 30 W.G.
RANGE OF WIDTHS 12 to 60 in.

BRABY for improved wrought **STEEL**
BARROWS, BOGIES, TRUCKS, GUTTERS, PIPES, &c.

BRABY for Iron and **STEEL**
ROOFS and BUILDINGS.

BRABY for unbreakable **STEEL**
SASHES, CASEMENTS, and PUTTYLESS ROOFLIGHTS.

BRABY for galvanized corrugated **STEEL**
SHEETS: "EMPRESS" and "SUN" BRANDS.

FREDERICK BRABY & Co., Ltd., Eclipse Iron and Galvanising Works and Steel Sheet Rolling Mills, Petershill Road, GLASGOW.

Show Rooms and Aluminium Warehouse, 124, St. Vincent Street, Glasgow.
Rustless Iron, Galvanising and Copper Works, FALKIRK.

Also at London, Deptford, Liverpool, Bristol, Belfast, and Dublin. CONTRACTORS to BRITISH and FOREIGN GOVERNMENTS. Telegrams—"Braby, Glasgow."

THOS. E. GRAY & CO.,

Contractors to
H.M. War Office.

3 & 4, LINCOLN'S INN FIELDS
KINGSWAY, LONDON, W.C.

Telegrams—"Papplewick, Holborn, London."
Telephone—Holborn 1946.

LOWEST PRICES FOR—

Best Washed Welsh Foundry Coke.
Best Durham Foundry Coke.
Special Brass Foundry Coke.
Best Quality Ground Ganister.
Nottinghamshire Red Sands.
Rolled Sand & Facing Loam.
Pure Plumbago
Limestone.
Smith's
Breeze.

SOLE AGENTS FOR THE MOST ECONOMICAL FOUNDRY COKE FOR USE IN M.R.V. OR MORGAN'S PATENT FURNACES.

Best Large Lancashire Foundry Coke.
Best Yorkshire Steel Coke.
Derbyshire Foundry Coke.
Worcestershire Red Sands
Superfine French and Belgian Sands.
(unequalled for Brass and Aluminium).
Coal Dust.
Anthracite, Steam and House Coal.
Smokeless Welsh Steam Wagon Coal.

COMPLETE PATTERN SHOP PLANT

LESS COST, LESS POWER, LESS ROOM—AND BETTER RESULTS.

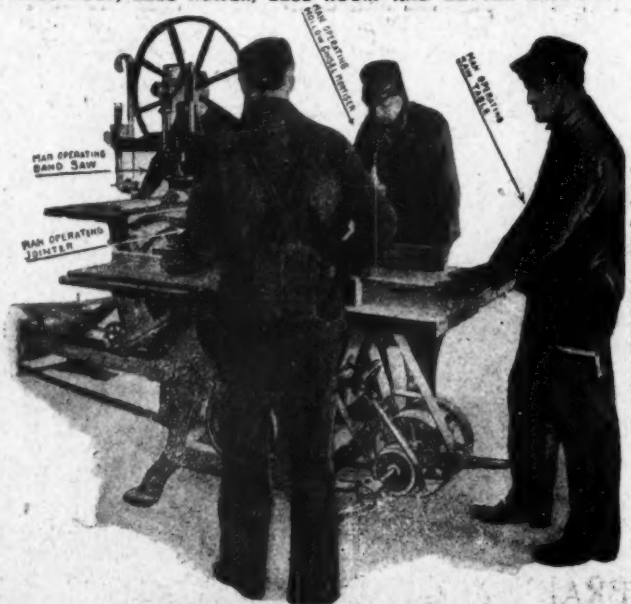
Which will pay for itself in six months.

1265 Universal Wood Workers in actual operation.

500 of this number built and sold in one year.

Made in 7 different sizes and for any particular purpose.

COMPLETE LINE OF WOOD WORKING MACHINERY KEPT IN STOCK FOR IMMEDIATE DELIVERY.



The Famous Universal Wood Worker.

Our Famous Universal Wood Worker, when equipped with all possible attachments, stands complete as a band saw, jointer, saw table, single spindle shaper, two-spindle borer, mortiser, tenoner, rim borer, felloe rounder, wheel equaliser, disc sander, drum sander, panel raiser and knife grinder.

Sole British, Colonial and Foreign Selling Agents—

UNIVERSAL MACHINERY CORPN. LTD., 328, OLD STREET, SHOREDITCH, LONDON, E.C.

THOS. BROADBENT & SONS, Ltd.

CENTRAL IRONWORKS, HUDDERSFIELD.

TRY A

BROADBENT CRANE

IN YOUR FOUNDRY

AND SAVE

TIME, LABOUR AND EXPENSE.

Tels: Broadbent, Huddersfield.
Tele: 1581 (4 lines).

London Office, Suffolk House,
Laurence Pountney Hill, E.C.

YOU CANNOT GET WRONG

WITH OUR

"CARLTON" PATENT BLACKING.

Can be used wet or dry on heavy or light castings. Always the same!

THOMAS WILKINSON & CO., LTD.,

Manufacturers, MIDDLESBROUGH.

FIRE BRICKS & CLAY

CUPOLA BRICKS.

Best Quality.

LESSEES OF DELPH AND TINTERN ABBEY BLACK AND WHITE CLAY.

KING BROTHERS,

(STOURBRIDGE) Ltd.,

STOURBRIDGE.

SANKEY

Fireproof

Steel Storage Bins

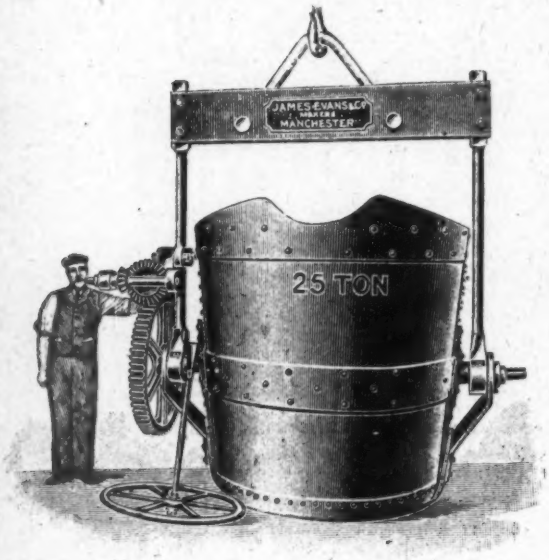
For Workshop or Warehouse.

Write for details.

Joseph Sankey & Sons Ltd.
Hadley. Salop.

FOUNDRY LADLES

OF ALL KINDS AND FOR ALL PURPOSES.



FROM 28 LBS. TO 50 TONS.

ASK FOR PRICE LIST.

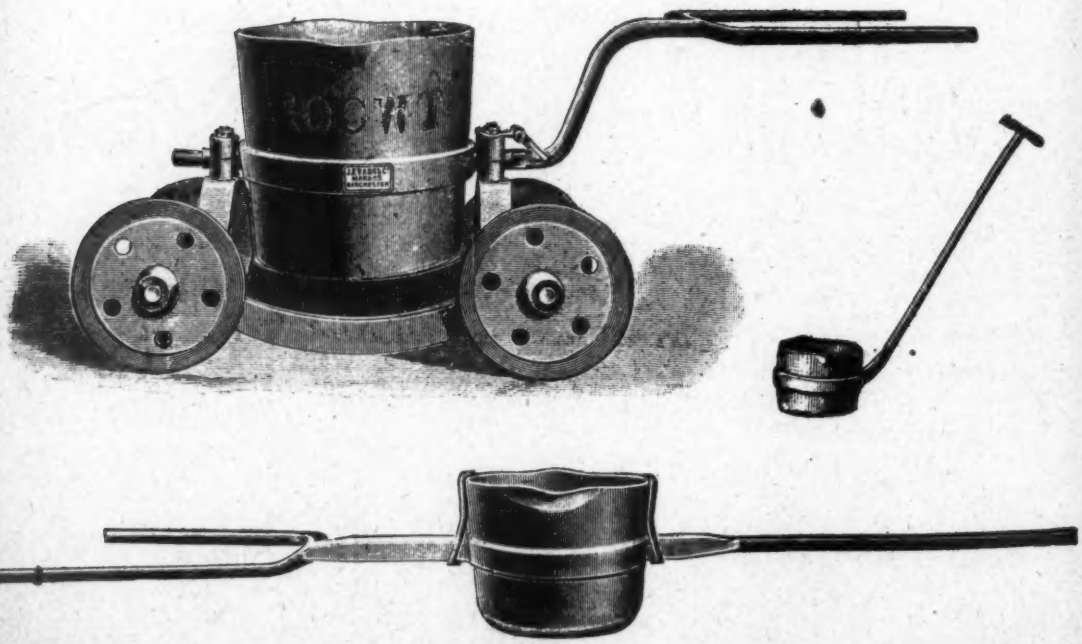
JAMES EVANS & CO.,

BRITANNIA WORKS.

BLACKFRIARS.

MANCHESTER.

TELEGRAMS "LADLES, MANCHESTER."
TELEPHONE 2297 CENTRAL, MANCHESTER.



EVERYTHING FOR THE FOUNDRY.